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Transportation Improvement Program

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NORTHERN MIDDLESEX

METROPOLITAN PLANNING ORGANIZATION

TRANSPORTATION IMPROVEMENT PROGRAM

FISCAL 1990

OCTOBER 1, 1989 - SEPTEMBER 30, 1990

Committee of Signatories

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Secretary, EOTC

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Northern Middlesex Metropolitan Planning Organization

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CERTIFICATION OF 3C TRANSPORTATION PLANNING PROCESS

In accordance with the FHWA/UMTA Urban Transportation Planning Final Rule, dated June 30, 1983, the Metropolitan Planning Organization (MPO) for the Northern Middlesex Urbanized Area has completed its review and hereby certifies that the conduct of the 3C Transportation Planning Process complies with the requirements of CFR 450.114 (c); and that said process includes activities to support the development and implementation of this Transportation Improvement Program (TIP), the Transportation Plan, and subsequent project development activities, as necessary and to the degree appropriate.

CERTIFICATION OF PRIVATE ENTERPRISE PARTICIPATION TRANSPORTATION PLANNING PROCESS

The Metropolitan Planning Organization (MPO) for the Northern Middlesex Urbanized Area hereby certifies that the local process for the involvement of the private sector in the transportation planning activity has been followed.

INTRODUCTION

Based on regulations promulgated by the Department of Transportation (DOT), any transportation project funded through the Federal Highway Administration (FHWA) or the Urban Mass Transportation Administration (UMTA) must be listed in the appropriate region's Transportation Improvement Program (TIP). Without such a listing, Federal Highway funds cannot be expended by the Massachusetts Department of Public Works (MDPW) on local or State projects. Similarly, the Lowell Regional Transit Authority (LRTA) can only receive Federal funds for projects listed in the TIP of the Northern Middlesex Metropolitan Planning Organization.

The principal object of this mandatory TIP listing is the provision of an additional point for public access to and review of the transportation planning process.

TIP Organization

The TIP divides projects between two time frames; the Annual Element (AE) and the Future Element (FE). Listed on the Annual Element are all the projects proposed for implementation in the current fiscal year. All other projects are generally considered to be not more than four years distant from entering the Annual Element and are thus listed in the Future Element.

Each element is subdivided so as to list separately individual projects under their appropriate funding category. Projects within each funding category are ranked by NMAC member community officials and citizens according to the locally perceived value of a project meeting regional transportation needs. This priority ranking is non-binding on the MDPW project implementation scheduling process. The ranking does, however, provide the MDPW with important local input regarding the relative value of individual projects within a given funding category.

TIP Development Process

The TIP is a requirement of the Federally mandated transportation planning process. This process is carried out under the authority of the Northern Middlesex Metropolitan Planning Organization (NMMPO) which reviews and endorses all required documents, and consists of: the Chairman of the Northern Middlesex Area Commission (NMAC), the Chairman of the Lowell Regional Transit Authority (LRTA), the Secretary of the Massachusetts Executive Office of Transportation and Construction (EOTC) and the Commissioner of the Massachusetts Department of Public Works (MDPW). The staff of NMAC acts as planning staff to the NMMPO. Under this arrangement NMAC produced the current TIP. The TIP is based on projects listed in the preceding year's TIP updated with current project listings provided by NMAC member

communities, the LRTA, and the MDPW. Priorities for each Annual Element project are suggested by NMAC staff, and submitted to member communities for their review. Following local review, the TIP is submitted to the NMMPO signatories for their official endorsement. Local review includes distribution of the draft document to private transit providers in the area according to NMAC Private Sector Involvement Policy.

As NMAC is the official areawide clearinghouse for Intergovernmental Review under Executive Order 12372, NMAC's endorsement of the TIP represents regional approval under the Federal Project Review System for all projects listed on the current TIP's Annual Element. This review also satisfies Statewide Intergovernmental Review requirements as set forth by Executive Office of Communities and Development Memorandum of July 18, 1986.

TIP Relationship to NMAC Comprehensive Transportation Plan

The Comprehensive Transportation Plan (CTP) covers a period of five to ten years and is updated as needed. NMAC is currently updating the CTP. The overall transportation goals and policies articulated in the CTP ensure that individual projects are considered within the context of established regional goals, as required by Federal regulation.

The TIP provides access to the funding necessary to transform the CTP's policies and goals into finalized projects. Many TIP Annual Element projects are drawn directly from the CTP. In addition to being drawn from the CTP, transit projects may be derived from special studies and routine capital equipment replacement schedules. The Gallagher Terminal addition (expansion of Gallagher Terminal to include a satellite bus facility and improved pedestrian access) is an example of this process. Special studies have included Development and Use Potential of the Gallagher Terminal, An Overview, NMAC, Fall 1981, LRTA Proposed Satellite Bus Facility and Pedestrian Access on Land Adjacent to Gallagher Terminal, NMAC, September 1984, Feasibility Study: Charles A. Gallagher Transportation Terminal Expansion, Satellite Facility/Pedestrian Access, NMAC, October 1987, Office Market Opportunities, Gallagher Transportation Terminal Site, Hammer Siler George Assoc.

TIP Position in Project Funding Sequence

Perhaps one of the most common misconceptions regarding highway project funding involves the relationship between project listing on the TIP and the assurance of funding for project construction.

The fact is that a highway project listing on the TIP does not in any way constitute a financial commitment to construct a

given project. Rather, TIP listing is simply, but importantly, one more step in the implementation process. This process requires, by regulation, that to be funded for construction, all projects must be listed on the TIP Annual Element. However, not all projects listed on the TIP must be funded for construction. In practice during any given year, more projects are listed in the Annual Element than there are available construction funds.

Deciding which projects are funded is the responsibility of the MDPW. Some of the criteria applied in this decision making process are regional priority, project cost, length of construction period and how a given project's completion affects the MDPW's overall transportation system improvement program.

Transit projects are also placed on the TIP prior to and as a necessary condition for commitment of funds by the Urban Mass Transportation Administration (UMTA). The LRTA includes the projects in the Annual Element on its annual Section 9, or other funding program, grant applications to UMTA. Actual funding is then determined by UMTA based on available funds and justification for the projects included in the grant application. As with highway projects, more projects may be programmed on the TIP than annual UMTA apportionments can accommodate. In these cases final priorities are set at the time grant applications are filed and alternate funding avenues or methods are sought through the LRTA's ongoing financial planning activities.

TIP AIR QUALITY ANALYSIS/CONSISTENCY STATEMENT

Introduction

To ensure that projects originating through the transportation planning process in the NMAC region are consistent with the State Implementation Plan (SIP) for air quality, an analysis of the Transportation Improvement Program (TIP) is required. This analysis is mandated only for those projects listed on the TIP Annual Element.

Within the Annual Element two main categories of projects require analysis: those which will affect existing vehicular speed, delay or usage, and those projects which are termed major action projects.

Projects in the first category are analyzed because of their bearing on the relationship between engine operation and mobile source (vehicular) pollution.

Engine Operation and Pollution

Briefly put, every time a vehicle engine is operated, it produces some degree of pollution. The degree of pollution is a function of engine operation as measured by speed in miles per hour (MPH). Generally, as vehicle speed (MPH) increases, engine pollution decreases. Consequently, the larger the percentage increase in speed, the greater the reduction in pollutants. Thus a 5 MPH increase from 30 MPH to 35 MPH produces a larger absolute emission reduction than a 5 MPH increase from 50 MPH to 55 MPH.

Projects Which Change Speed, Delay, Usage:

- Speed - Generally (though not exclusively), projects which increase the operating speeds of a given roadway do so by increasing its capacity. Increased capacity - the ability of a roadway to accommodate more vehicles at one time - results from widening the existing roadway. Thus projects which involve widening a roadway are analyzed.

- Delay - Because there is no clean phase of engine operation, engine idling, termed vehicle delay or simply delay, is a significant contributing factor to mobile source pollution. Typically, signalization projects have a direct bearing on the amount of delay at a given location. For that reason, signalization projects on the Annual Element are analyzed.

- Usage - Because once in operation a vehicle engine is constantly producing pollution, any project which influences the amount of vehicle usage has a direct

impact on air quality. Therefore, projects such as park and ride lots and new transit service which influence use are analyzed.

Major Action Projects

The second category of projects included in this analysis are those which, due to project nature and/or scope, require, by law, that an Environmental Impact Statement (EIS), Environmental Impact Review (EIR) or Finding of No Significant Impact (FONSI) be conducted. These studies document a given project's impact on various systems and elements one of which is air quality.

This consistency analysis takes note of all major action projects listed on the Annual Element. Following completion of these projects' respective reports, NMAC will examine the appropriate air quality data and include it in this analysis. Each annual project which fulfills any of the above definitions is labeled as having Air Quality Significance in its TIP project description.

Methodology

Each project analysis utilizes the methodology developed by the DEQE and MDPW and endorsed by the Air Quality Task Force. Within each analysis the following factors were employed:

- ADT - Existing ADT is factored from base year data to the appropriate study year.
- Emission factors - all factors are from EPA Mobile II.
- 1987 emission factors are adjusted annually using the .86 adjustment factor to reflect 1990 conditions as suggested by DEQE in its August 31, 1987 memo on TIP Analysis Technical Guidance.
- Default noncatalytic/cold/hot start of 20.6%/27.3%/ 20.6%.
- 75° F ambient temperature.
- All emission totals expressed in kilograms. Note 453.7 grams = 1 pound while 1,000 grams = 1 kilogram.

The results of the analysis described above are illustrated in Table 1.

TABLE 1

NMAC FY 1990 TIP A.E. AIR QUALITY FINDINGS

Community	Project	Funding Category Cost	Change in Non-Methane Hydrocarbon Per Ozone Season* 1990
Billerica	Route 3A Signalization Projects	Urban Systems Statewide $1,250,000.	+89.71 kg
Lowell	Reconstruct Pawtucket Blvd. (Route 113) for a total of 1.96 miles	Urban Systems Statewide $3,500,000.	-102.21 kg
Westford	Route 110/ Minott's Corner	Rural Secondary $1,500,000.	+10.31 kg

Conclusion

This analysis of the NMAC FY 1990 TIP reveals that the three signal improvement projects proposed for Route 3A in Billerica and the Minott's Corner improvements have the potential to increase non-methane hydrocarbons by 100.2 kg in 1990. However, the reconstruction of Pawtucket Boulevard in Lowell will reduce overall levels of non-methane hydrocarbons by 102.21 kg in 1990.

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* Ozone Season = 180 days

DESCRIPTION OF FUNDING CATEGORIES

The explanations which follow outline the basic uses and requirements of each funding category utilized in this TIP. Specific information related to a particular roadway's eligibility for these funds can be provided by NMAC (454-8021) or the MDPW District 4 Office (648-6100). Questions regarding UMTA funding are best directed to the LRTA (459-0164).

Highway Funding

o Interstate - Finances construction projects on the Interstate System regardless of the urban or rural nature of a project's location. The NMAC region has sections of two operating Interstate facilities, I-495 and I-93, within its boundaries.

Funding: Federal 90%/State 10%.

o Interstate Resurfacing, Restoration, Rehabilitation and Reconstruction (I-4R) - Contributes to financing the major maintenance requirements of the Interstate System.

Funding: Federal 90%/State 10%.

o Urban Systems - Finances construction and maintenance projects on Urban System roadways such as the Middlesex Turnpike and the Lowell Connector. Typically, Urban System facilities are owned by local communities and are high traffic volume arterials or collectors situated in urban areas. For highway planning purposes, the MDPW designates which sections of the highway network are urban or rural.

Funding: Federal 75%/State 25%/Local 100% of design costs.

o Consolidated Primary - Finances construction and maintenance projects on roadways such as Route 3, which are usually rural arterials inclusive of their urban extensions. Again the MDPW (with the approval of DOT) establishes which roads make up the Primary System. Generally, the entire Primary System is State owned.

Funding: Federal 75%/State 25%.

o Rural Secondary - Finances construction and maintenance projects on roadways such as Route 113 in Dunstable which are major collector routes located in areas deemed rural by the MDPW.

Funding: Federal 75%/State 25%.

o Highway Bridge Replacement and Rehabilitation - Finances the replacement or maintenance of deficient bridges without concern for a given bridge's urban or rural setting. Uniquely, these funds may be expended on any highway bridge situated on a public road whether on or off the Federal Aid System. Projects such as replacement of the School Street Bridge in Lowell and the High Street Bridge in Billerica qualify for this category.

Funding: Federal 80%/State 20%.

o Public Works Economic Development (PWED) - Finances roadway projects (such as construction of access roads) which will directly encourage the economic development of the surrounding area.

Funding: Program does not specify amounts of matching funds.

o Rail Highway Crossings Program - Finances projects which eliminate hazards at railroad highway crossings, again regardless of the urban or rural character of a project's location. Typically, projects which meet this category's requirements are grade separations and the installation of flashing lights or gates or signs at rail-highway crossings.

Funding: Federal 90%/State 10%.

o Safer Off-Systems - Finances projects to upgrade and reconstruct non-toll publicly owned roads in both urban and rural areas not on the Federal Aid System.

Funding: Federal 75%/State 25%.

o State Aid - Bikeways - Finances the design, construction or reconstruction of bicycle paths, lanes or routes in either an urban or rural area.

Funding: State 75%/Local 25%, which may be provided through in-kind services.

o Non-Federal Aid Roadways - Finances the construction or reconstruction, improvement or maintenance of any municipally or county owned road whether urban or rural, except State highways.

Funding: For roads on the State Aid Primary System, the State pays 100% of costs. For non-State Aid Primary System Roads, the funding is State 75% and local 25%.

Transit Funding

o Section Nine (UMTA) - Finances capital, planning and operating expenses for LRTA urban service areas. Section 9 funds are awarded and administered by UMTA.

Funding for capital expenses: Federal 80%/State 10%/ LRTA 10%.

Funding for planning expenses: Federal 80%/NMAC 20%.

Funding for operations expenses: Federal 50%/State 25%/ LRTA 25%.

o Section 18 (UMTA) - Finances capital and operating expenses for transit operations in rural areas. In Massachusetts, this section is administered by the Executive Office of Transportation and Construction (EOTC).

Funding for operating expenses: Federal 50%/State 25%/ LRTA 25%.

Funding for capital expenses: Federal 80%/State 10%/ LRTA 10%.

o Section 16(b) (2) (UMTA) - Finances capital expenses for private non-profit organizations to provide specialized transit services for the elderly and handicapped populations. These awards are approved on a project by project basis, funding only capital expenses for the acquisition of specific types of vans and base station equipment. Section 16(b) (2) does not fund operating expenses under any conditions.

Funding: Federal 80%. Private non-profit organization 20% paid in cash with non-Federal funds.

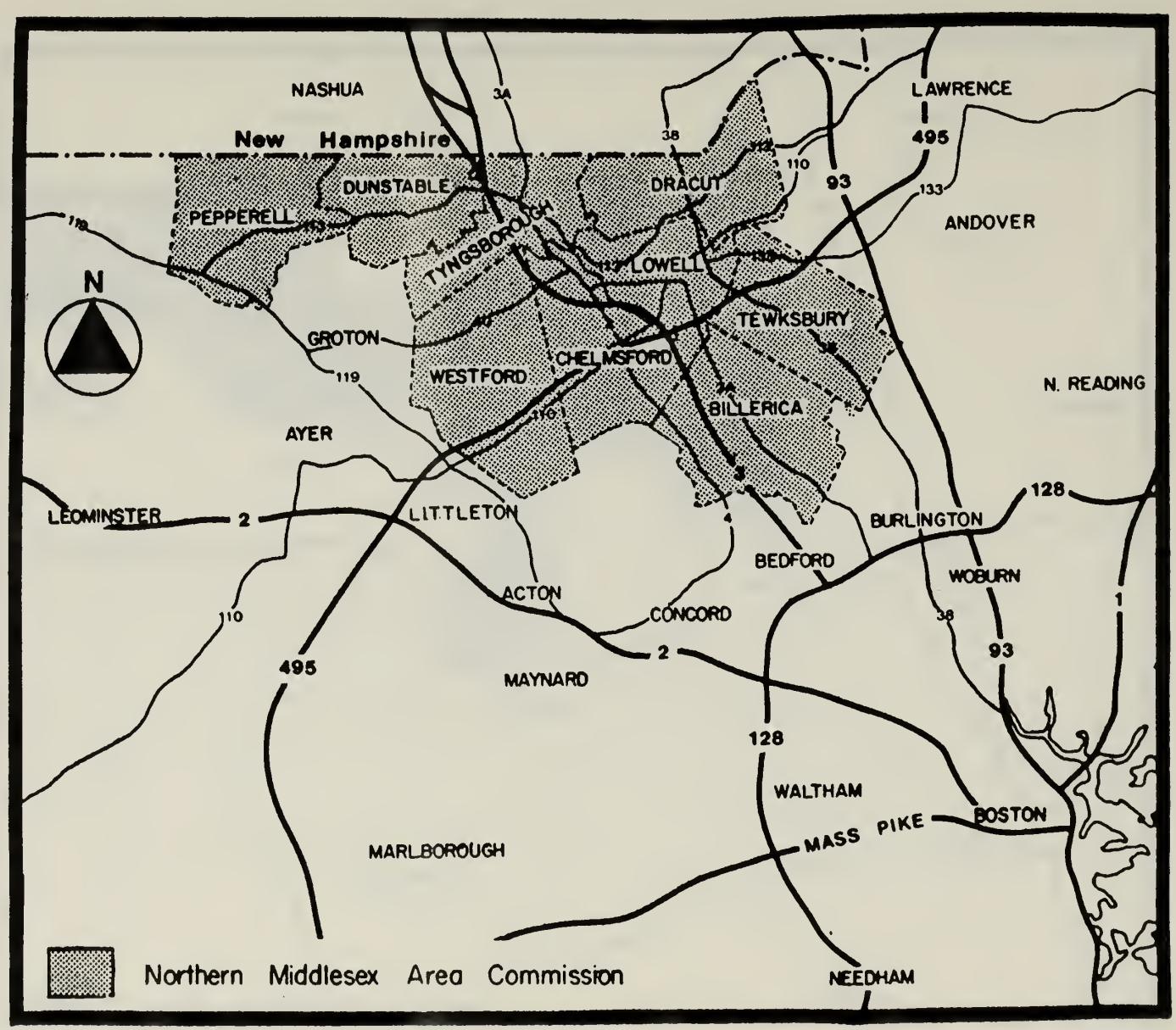
Annual Element Project Totals (Highway)

Table 2 shows the total annual element project costs by funding category. Estimated funding for FY '89 is not yet available, however, based on past years' available funding levels, many funding categories for NMAC TIP project totals would use a large percentage of funds available statewide. This fact points to the extremely competitive nature that exists in funding highway projects.

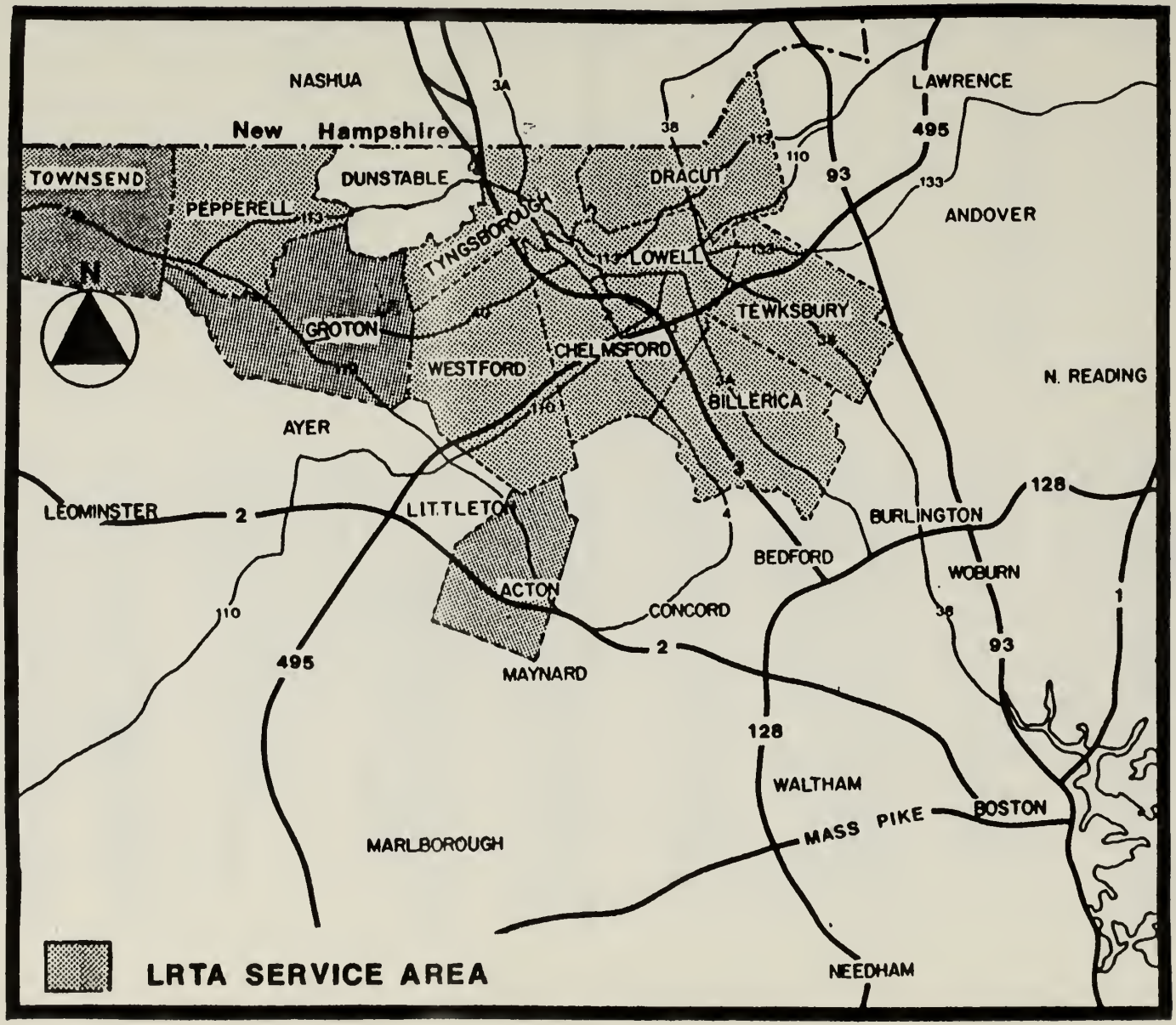
TABLE 2

Category	Annual Element Project Totals
Urban Systems	$4,750,000.
Highway Bridge Replacement and Rehabilitation	3,200,000.
Interstate Resurfacing	3,400,000.
Rural Secondary	1,500,000.
Consolidated Primary	6,000,000.

NORTHERN MIDDLESEX AREA COMMISSION REGION



LOWELL REGIONAL TRANSIT AUTHORITY SERVICE AREA



LEXICON

The terms defined below are used throughout the Transportation Improvement Program (TIP).

Activity -	Proposal, planning, engineering (PE), right of way (ROW) or construction (CON) as appropriate for a given project's status.
Air Quality Significance (AQS) -	Indicates a project which influences vehicle speed, delay or usage. (Pg.6)
Annual Element (AE) -	TIP section listing projects proposed for implementation during the current Federal fiscal year (October 1st to September 30th). (Pg. 1)
Future Element (FE) -	TIP section listing projects expected to enter the AE within the next four fiscal years.
Implementing Agency -	Identifies agency or agencies responsible for a project's planning, design and construction.
Regional Priority -	Project ranking approved by NMAC communities and endorsed by the Committee of Signatories (Pg. 1); 1-High; 2-Medium; 3-Low.
Source of Funds -	Level of government(s) - Federal, State, Local - financing a project's implementation.
"T" -	"T" notes a project contained in the current Comprehensive Transportation Plan.
TSM -	Notes a project which employs Transportation System Management (TSM) methods to solve a transportation problem.

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$ $ $ $

Federal 75%
State 25%
Local 100% of design costs for locally owned facilities

URBAN SYSTEMS STATEWIDE

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Boston Road/ Route 3A Billerica A.Q.S. T	Traffic signals at Boston Road and Treble Cove Road, Boston Road and Bridge Street, Boston Road and Webb Brook Road (Design work complete) Project I.D.#: 006820	1	Federal State Local Total Activity	937.5 312.5 _____ 1250 CON	PE by Town CON by MDPW
Pawtucket Boulevard (Route 113) Lowell A.Q.S. T	Reconstruct and relocate Pawtucket Boulevard along northerly edge from Dunbar Avenue to Pawtucket Boulevard Extension (1.96 miles) (Design work complete) Project I.D.#: 056050	1	Federal State Local Total Activity	2625 875 _____ 3500 RECON	PE by City RECON by MDPW
			Federal State Local Total Activity		
			Federal State Local Total Activity		
			Federal State Local Total Activity		

$ $ $ $

Federal 80%
State 20%
Local

BRIDGE REPLACEMENT/REHABILITATION

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Bridges in NMAC communities	Necessary preliminary engineering/design as bridges require in NMAC communities		Federal	160	MDPW
			State	40	
			Local		
			Total	200	
			Activity	PE	
Boylston Street Lowell L-15-5	Reconstruction of Boylston Street bridge over the B&M Railroad	2	Federal	800	MDPW
			State	200	
			Local		
			Total	1000	
T	Project I.D.#: 007105		Activity	RECON	
School Street Bridge, Lowell L-15-22	Design work for rehabilitation of School Street Bridge over Northern Canal	2	Federal	160	MDPW
			State	40	
			Local		
			Total	200	
T	Project I.D.#: 127750		Activity	DESIGN	
Plain Street Bridge, Lowell L-15-2	Design work for rehabilitation of Plain Street Bridge over ConRail tracks	1	Federal	80	MDPW
			State	20	
			Local		
			Total	100	
T	Project I.D.#: 056550		Activity	DESIGN	
Main Street Bridge Tewksbury T-3-8	Design work for the reconstruction of Main Street Bridge over B&M Railroad	1	Federal	720	MDPW
			State	180	
			Local		
			Total	900	
T	Project I.D.#: 042230		Activity	DESIGN	

$ $ $ $

Federal 80%
State 20%
Local

BRIDGE REPLACEMENT/REHABILITATION

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Gray Street Bridge Billerica B-12-12	Design work for total bridge replacement	1	Federal	80	MDPW
			State	20	
			Local		
			Total	100	
T	Project I.D.#: 029449		Activity	DESIGN	
Andover Road Bridge Billerica B-12-13	Design work for total bridge replacement	1	Federal	80	MDPW
			State	20	
			Local		
			Total	100	
T	Project I.D.#: 002001		Activity	DESIGN	
Pollard Street Bridge Billerica B-12-5	Design work for bridge reconstruction	2	Federal	144	MDPW
			State	36	
			Local		
			Total	180	
T	Project I.D.#: 058020		Activity	DESIGN	
Phineas Street Bridge Dracut D-11-5	Design for replacement of existing bridge and related approach roadway	1	Federal	96	MDPW
			State	24	
			Local		
			Total	120	
T	Project I.D.#: 021110		Activity	DESIGN	
Brown Street Bridge Billerica B-12-14	Design work for bridge replacement	1	Federal	80	MDPW
			State	20	
			Local		
			Total	100	
T	Project I.D.#: 009549		Activity	DESIGN	

$ $ $ $

Federal 80%
State 20%
Local

BRIDGE REPLACEMENT/REHABILITATION

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
School Street Bridge Lowell L-15-10	Design work Replace School Street Bridge over railroad tracks and canal	1	Federal	160	MDPW
			State	40	
			Local		
			Total	200	
T	Project I.D.#: 127751		Activity	DESIGN	
River Street Bridge Westford W-26-10	Design work Replace River Street Bridge over B&M Railroad	1	Federal	80	MDPW
			State	20	
			Local		
			Total	100	
	Project I.D.#: 060950		Activity	DESIGN	
			Federal		
			State		
			Local		
			Total		
			Activity		
			Federal		
			State		
			Local		
			Total		
			Activity		
			Federal		
			State		
			Local		
			Total		
			Activity		

$ $ $ $

Federal 90%
State 10%
Local

INTERSTATE RESURFACING (4R)

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
I-495 Westford	Resurface I-495 from Chelmsford/ Westford Town line to Littleton/ Boxborough Town line	1	Federal	2700	MDPW
			State	300	
			Local		
			Total	3400	
	Project I.D.#: 066162		Activity	RESUR	
			Federal		
			State		
			Local		
			Total		
			Activity		
			Federal		
			State		
			Local		
			Total		
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			Activity		
			Federal		
			State		
			Local		
			Total		
			Activity		

$ $ $ $

Federal 90%
State 10%
Local

RURAL SECONDARY

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Route 110/ Minott's Corner Westford	Traffic and intersection improvements, including signalization of Minott's Corner Project I.D.#: .080649	1	Federal State Local Total Activity	1350. 150. 1500. CON	PE by Town CON by MDPW
			Federal State Local Total Activity		
			Federal State Local Total Activity		
			Federal State Local Total Activity		
			Federal State Local Total Activity		

$ $ $ $

Federal 75%
State 25%
Local

CONSOLIDATED PRIMARY

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Route 3 Billerica, Chelmsford, Lowell	Design work Route 3 Add-A-Lane project from Route 128 to New Hampshire State line (Phase II - Billerica to New Hampshire State line)	1	Federal	4500	MDPW
			State	1500	
			Local		
			Total	6000	
T	Project I.D.#: 107700		Activity	CON	
			Federal		
			State		
			Local		
			Total		
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			Federal		
			State		
			Local		
			Total		
			Activity		

$ $ $ $

Federal 75%
State 25%
Local 100% of design costs for locally owned facilities

URBAN SYSTEMS STATEWIDE

FE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Merrimack St., Dutton St., and Arcand Dr. Lowell	Reconstruction of the intersection of Merrimack Street, Dutton Street, and Arcand Drive (Monument Square)	2	Federal	525	Design by City
			State	175	CON by MDPW
			Local		
			Total	700	
T	Project I.D.#: 040405		Activity	CON	
Route 38/ Rogers Street Lowell	Improvements on Route 38/Rogers Street corridor	1	Federal	412.5	PE by Lowell Plan
			State	137.5	CON by MDPW
			Local		
			Total	550	
T	Project I.D.#: 112180		Activity	CON	
Route 129 Chelmsford	Reconstruction of Route 129 from Alpha Road to Industrial Avenue	1	Federal	1425	PE by Town
			State	475	CON by MDPW
			Local		
			Total	1900	
T	Project I.D.#: 089003		Activity	CON	
Thorndike St. Lowell	Reconstruction of Thorndike St. from Lowell Connector to the beginning of the Sampson Connector	1	Federal	600	PE by City
			State	200	CON by MDPW
			Local		
			Total	800	
T	Project I.D.#: 133912		Activity	RECON	
			Federal		
			State		
			Local		
			Total		
			Activity		

$ $ $ $

Federal 75%
State 25%
Local

RURAL SECONDARY

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Route 113 Pepperell	Channelization of Main Street and Groton Street at Railroad Square	2	Federal	375	Preliminary design underway by Town
			State	125	
			Local		
			Total	500	
T	Project I.D.#: 081601		Activity	CON	
			Federal		
			State		
			Local		
			Total		
			Activity		
			Federal		
			State		
			Local		
			Total		
			Activity		
			Federal		
			State		
			Local		
			Total		
			Activity		
			Federal		
			State		
			Local		
			Total		
			Activity		

$ $ $ $

Federal 80%
State 20%
Local

BRIDGE REPLACEMENT/REHABILITATION

FE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
School Street Bridge Lowell L-15-22	Replace or substantially rehabilitate School Street Bridge over Northern Canal	2	Federal	1600	MDPW
			State	400	
			Local		
			Total	2000	
T	Project I.D.#: 127750		Activity	RECON	
Plain Street Bridge, Lowell L-15-2	Replace or substantially rehabilitate Plain Street Bridge over ConRail tracks	1	Federal	800	MDPW
			State	200	
			Local		
			Total	1000	
T	Project I.D.#: 056550		Activity	RECON	
Gray Street Bridge Billerica B-12-12	Total bridge replacement	1	Federal	800	MDPW
			State	200	
			Local		
			Total	1000	
T	Project I.D.#: 029449		Activity	RECON	
Andover Road Bridge Billerica B-12-13	Total bridge replacement	1	Federal	800	MDPW
			State	200	
			Local		
			Total	1000	
T	Project I.D.#: 002001		Activity	RECON	
			Federal		
			State		
			Local		
			Total		
			Activity		

$ $ $ $

Federal 80%
State 20%
Local

BRIDGE REPLACEMENT/REHABILITATION

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Aiken Street Bridge Lowell L-15-20	Bridge reconstruction	1	Federal	4000	MDPW
			State	1000	
			Local		
			Total	5000	
T	Project I.D.#: 000910		Activity	RECON	
Pollard Street Bridge Billerica B-12-5	Bridge reconstruction	2	Federal	1440	MDPW
			State	360	
			Local		
			Total	1800	
T	Project I.D.#: 058020		Activity	RECON	
Permanent river crossing over Merrimack River Lowell	New bridge across Merrimack River	1	Federal	36000	MDPW
			State	9000	
			Local		
			Total	45000	
T	Project I.D.#: 103000		Activity	CON	
Phineas Street Bridge Dracut D-11-5	Complete replacement of existing bridge and related approach roadway	1	Federal	960	MDPW
			State	240	
			Local		
			Total	1200	
T	Project I.D.#: 021110		Activity	RECON	
Route 111/119 Bridge Pepperell P-6-1	Reconstruct bridge over Nashua River	2	Federal	640	MDPW
			State	160	
			Local		
			Total	800	
T	Project I.D.#: 029910		Activity	RECON	

$$$$

Federal 80%
State 20%
Local

BRIDGE REPLACEMENT/REHABILITATION

FE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Brown Street Bridge Billerica B-12-14	Total bridge replacement	1	Federal	800	MDPW
			State	200	
			Local		
			Total	1000	
T	Project I.D.#: 009549		Activity	CON	
Princeton Street (Route 3A) Bridge Chelmsford C-8-3	Bridge reconstruction	2	Federal	67.5	MDPW
			State	22.5	
			Local		
			Total	90	
T	Project I.D.#: 109800		Activity	CON	
School Street Bridge Lowell L-15-10	Replace School Street Bridge over Railroad tracks and Canal	1	Federal	1600	MDPW
			State	400	
			Local		
			Total	2000	
T	Project I.D.#: 127751		Activity	CON	
Concord Road Bridge over Route 3 Billerica B-12-21	Replace bridge decking on Concord Road Bridge over Route 3	1	Federal	280	MDPW
			State	70	
			Local		
			Total	350	
T	Project I.D.# 016430		Activity	CON	
River Street Bridge Westford W-26-10	Replace River Street Bridge over B&M Railroad	1	Federal	800	MDPW
			State	200	
			Local		
			Total	1000	
	Project I.D.#060950		Activity	CON	

Federal 90%
State 10%
Local

HAZARD ELIMINATION

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Five intersection improvements Lowell T	Signal installations and related geometric improvements at the following five intersections: 1. Aiken Street/Lakeview Avenue 2. Pine Street/Stevens Street 3. Westford Street/Pine Street 4. Westford Street/Stevens St. 5. Aiken Street/W.Sixth Street Project I.D.#: 025705	2	Federal State Local Total Activity	348.3 38.7 — 387 PE	MDPW
			Federal State Local Total Activity		
			Federal State Local Total Activity		
			Federal State Local Total Activity		

$ $ $ $

Federal 75%
State 25%
Local

CONSOLIDATED PRIMARY

FE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Route 3 Billerica, Chelmsford, Lowell	Route 3 Add-A-Lane Project from Route 128 to New Hampshire State line (Burlington to Billerica - Phase I Billerica to New Hampshire - Phase II)	1	Federal	45000	MDPW
			State	15000	
			Local		
			Total	60000	
T	Project I.D.#: 107700		Activity	CON	
Route 3 Chelmsford, Westford, Tyngaborough	Resurface from Route 4 interchange (Drum Hill Rotary) to the New Hampshire State line	1	Federal	7275	MDPW
			State	2425	
			Local		
			Total	9700	
	Project I.D.#: 108570		Activity	RESUR	
			Federal		
			State		
			Local		
			Total		
			Activity		
			Federal		
			State		
			Local		
			Total		
			Activity		
			Federal		
			State		
			Local		
			Total		
			Activity		

COMMUNITY MAPS - PROJECT LOCATIONS

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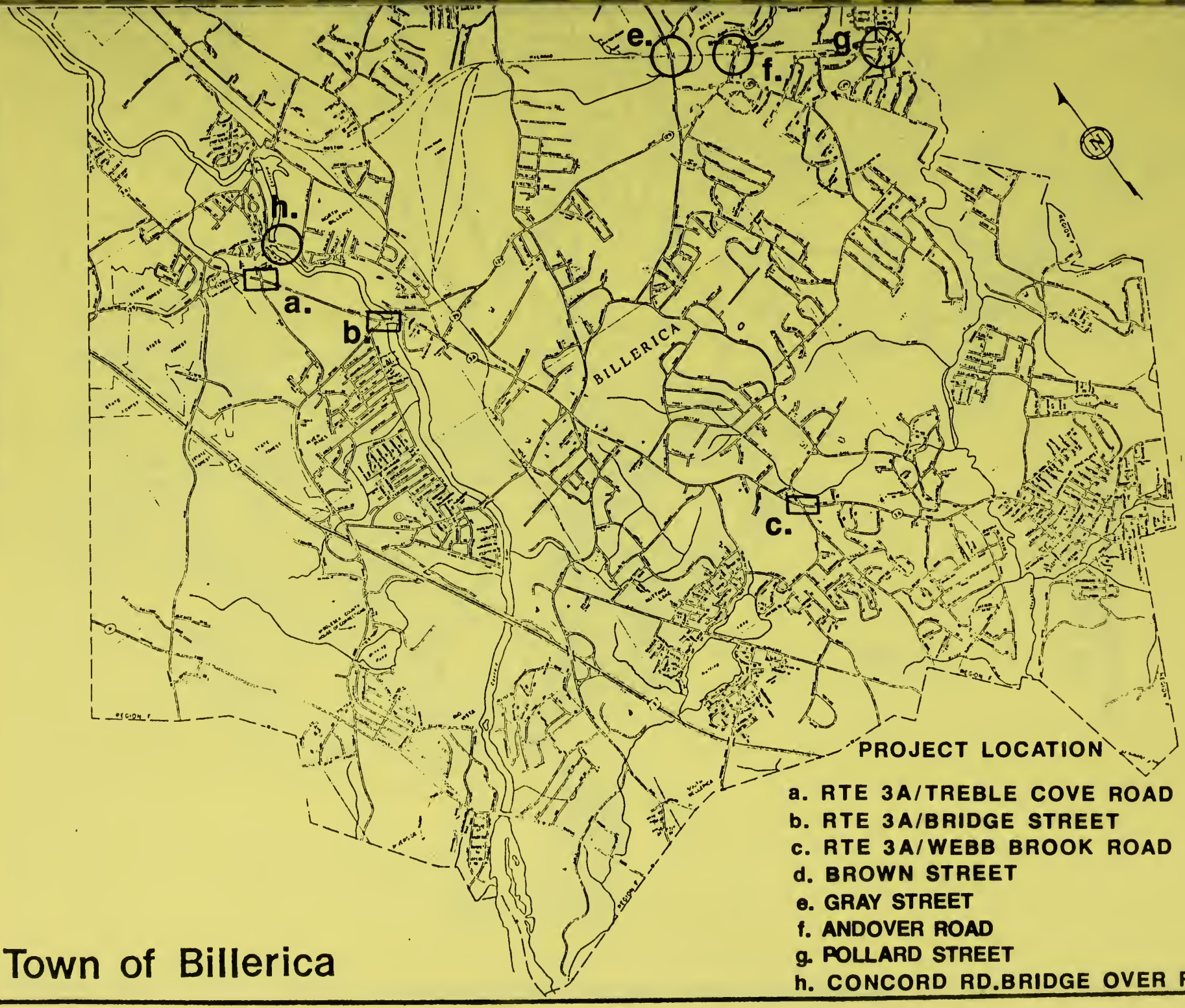
Dracut	m-3
Lowell	m-4
Pepperell	m-5
Tewksbury	m-6
Westford	m-7

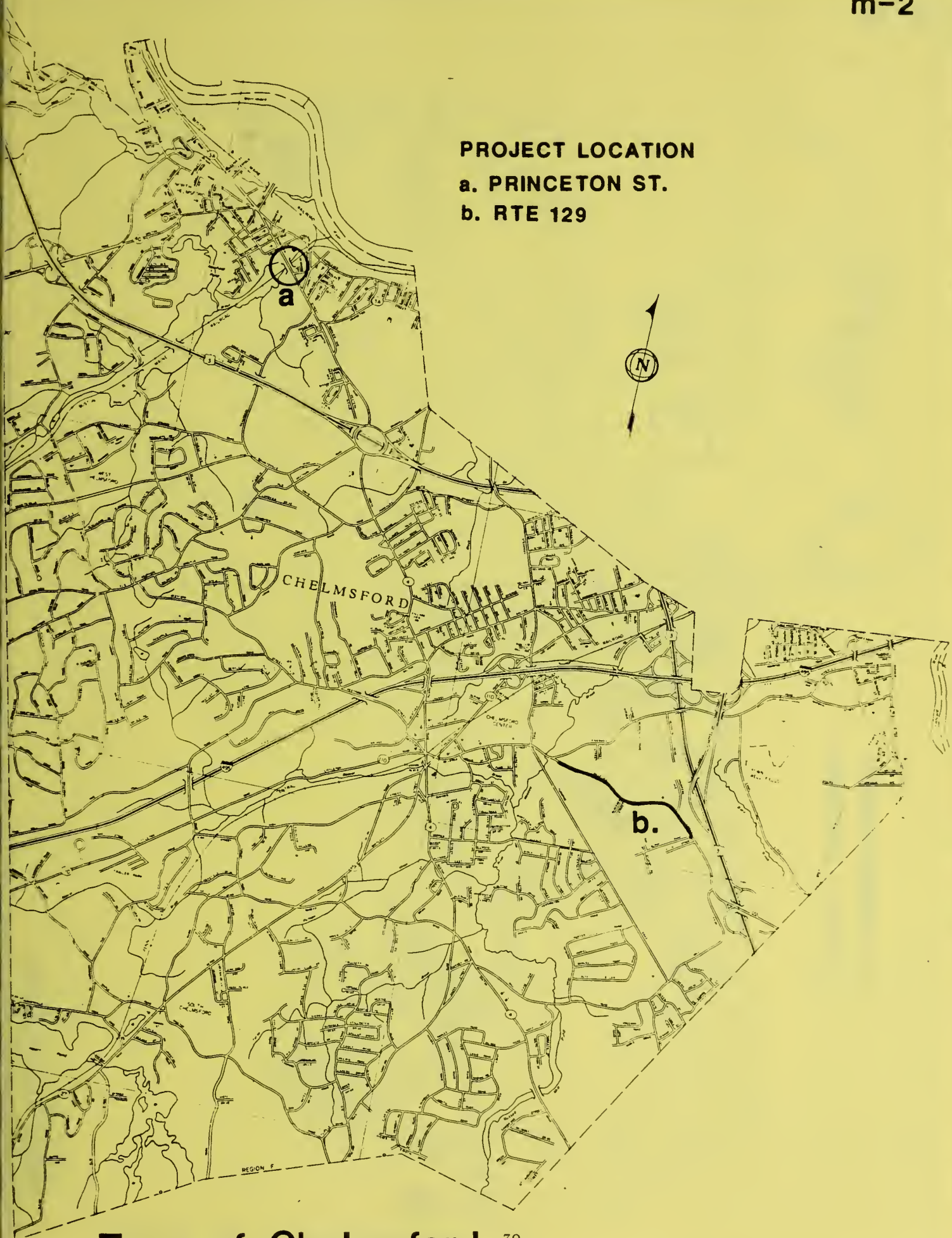
KEY

○	Bridge
□	Intersection
\ OR ◇	Road Work



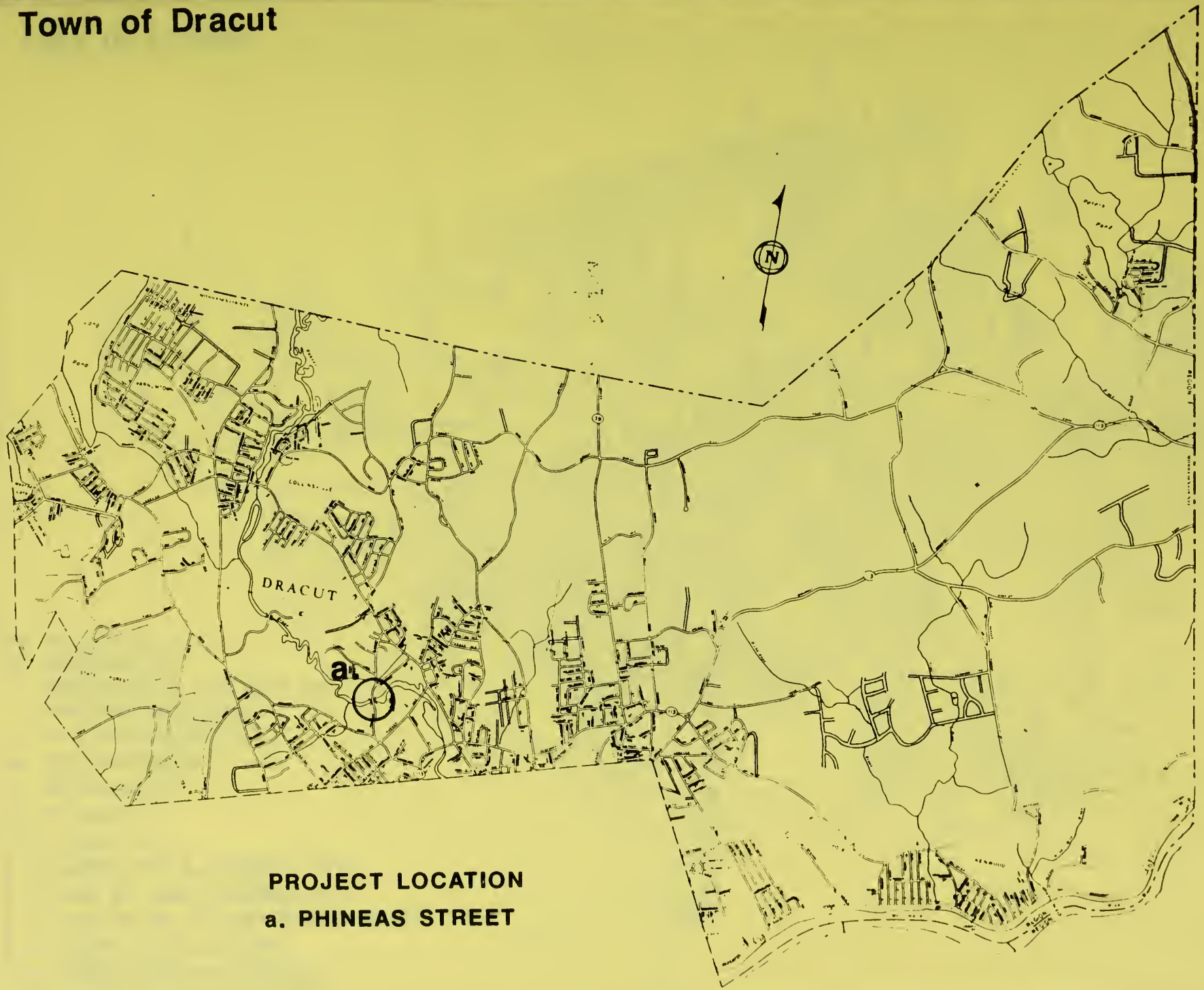
Town of Billerica

M-1


PROJECT LOCATION
a. PRINCETON ST.
b. RTE 129
a
b.
N
CHELMSFORD
REGION F

Town of Dracut

Town of Dracut



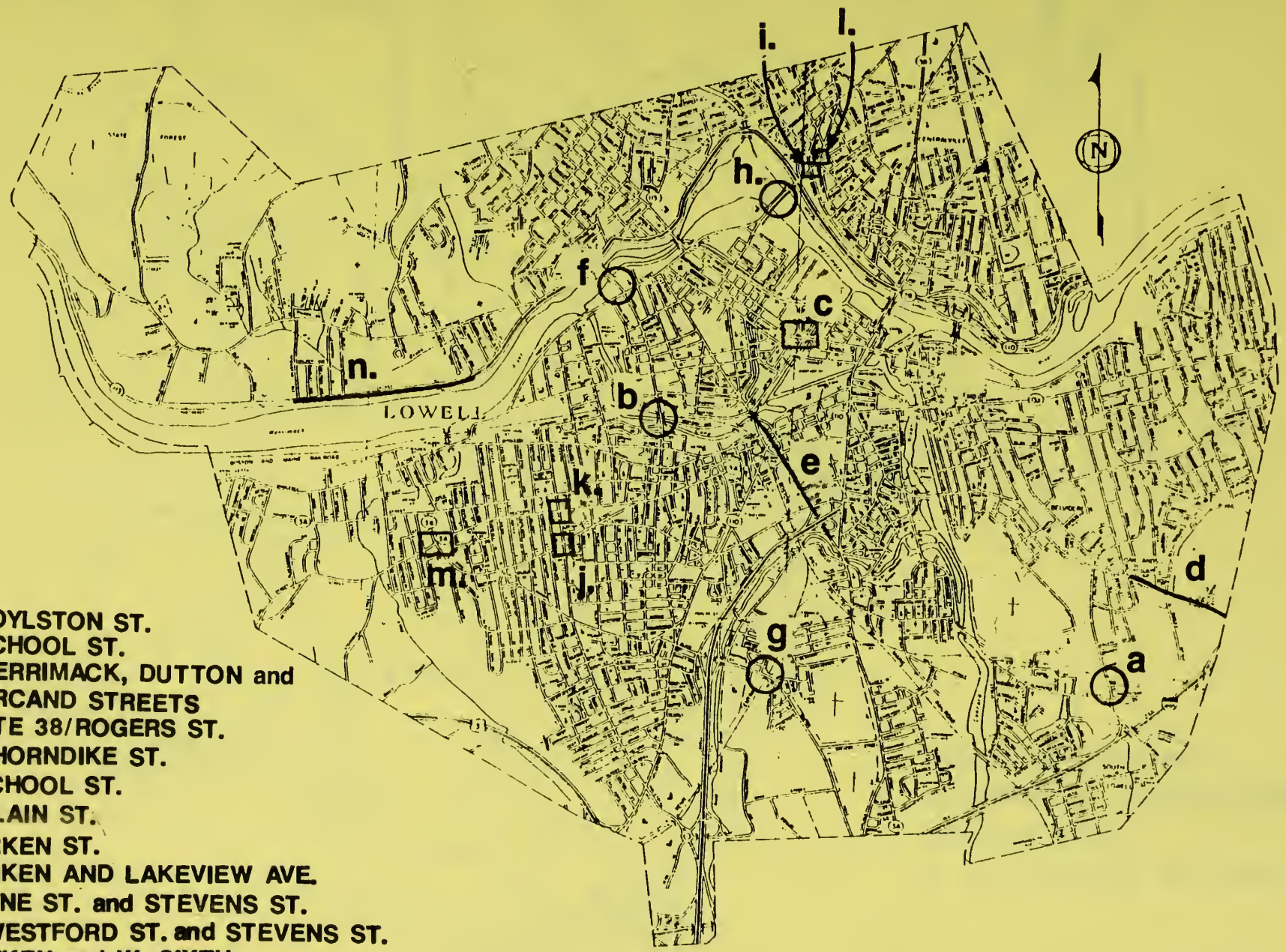
PROJECT LOCATION

a. PHINEAS STREET

m-3

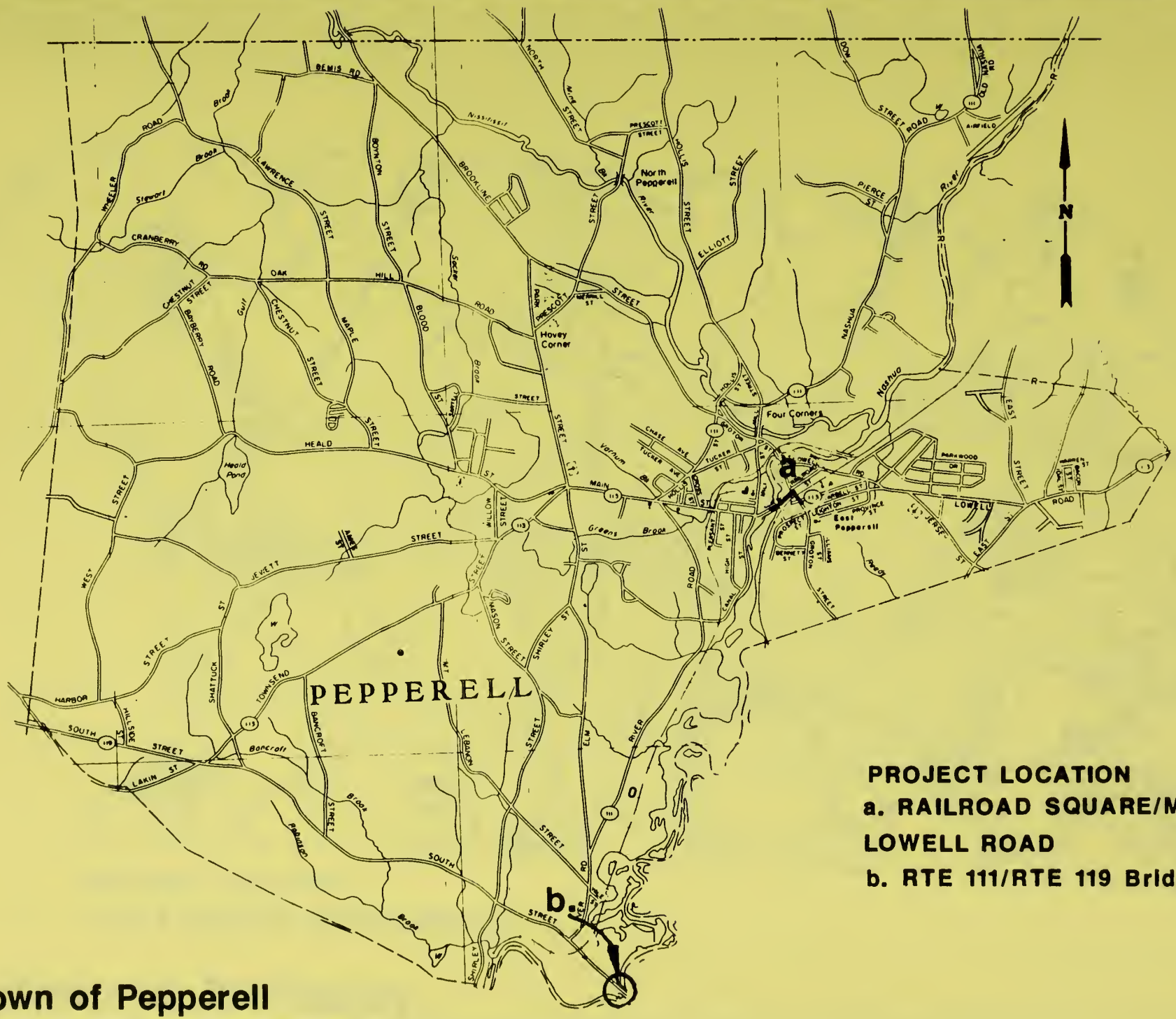
City of Lowell

City of Lowell



a. BOYLSTON ST.
b. SCHOOL ST.
c. MERRIMACK, DUTTON and ARCAND STREETS
d. RTE 38/ROGERS ST.
e. THORNDIKE ST.
f. SCHOOL ST.
g. PLAIN ST.
h. AIKEN ST.
I. AIKEN AND LAKEVIEW AVE.
j. PINE ST. and STEVENS ST.
k. WESTFORD ST. and STEVENS ST.
l. AIKEN and W. SIXTH
m. WESTFORD and PINE ST.
n. PAWTUCKET BOULEVARD

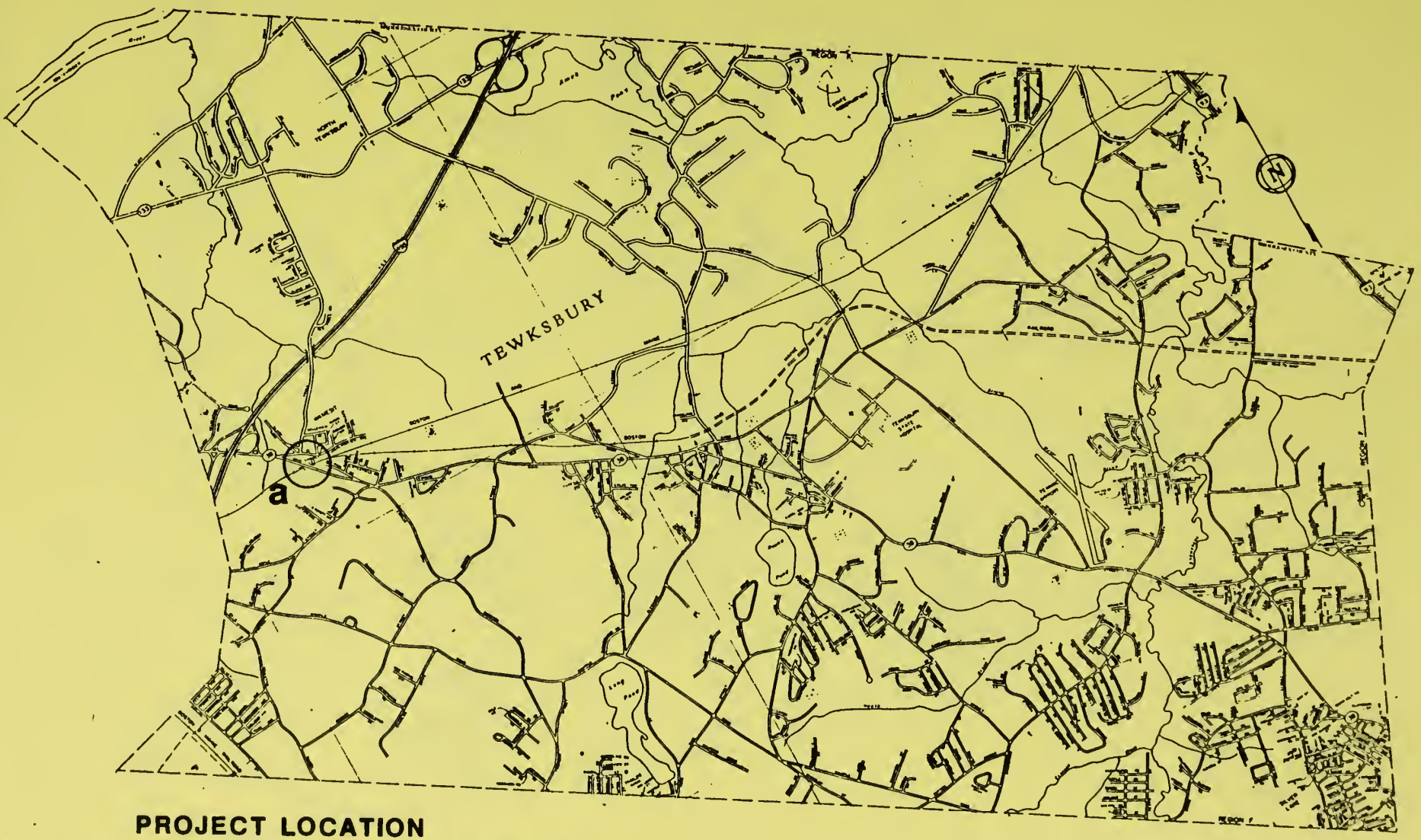
m-4



PROJECT LOCATION
a. RAILROAD SQUARE/MAIN ST./LOWELL ROAD
b. RTE 111/RTE 119 Bridge

Town of Pepperell

III-5

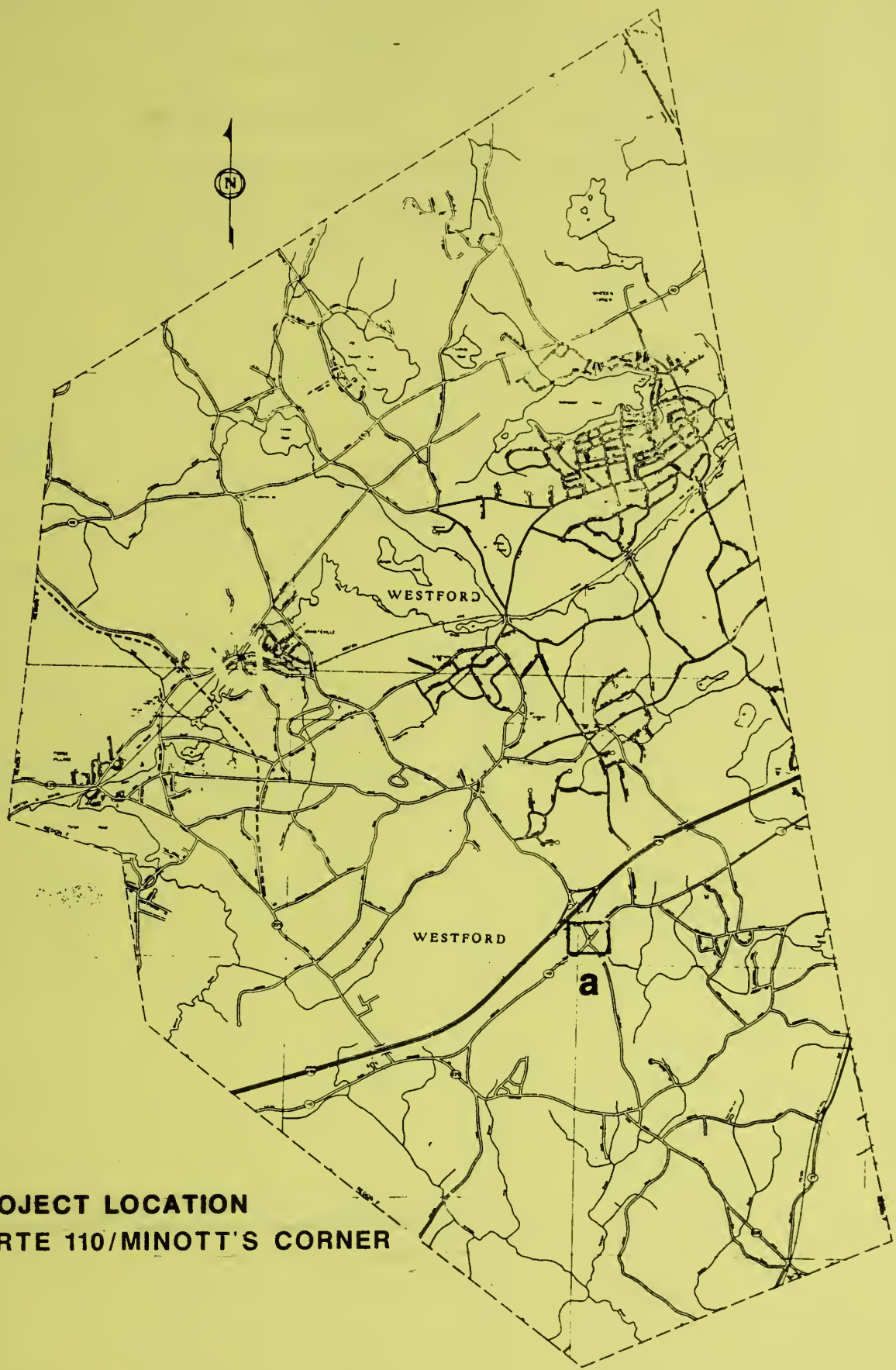


PROJECT LOCATION

a. RTE 38/MAIN STREET BRIDGE

Town of Tewksbury

m-6



PROJECT LOCATION
a. RTE 110/MINOTT'S CORNER

Town of Westford

$ $ $ $

	Capital	Operating
Federal	80%	50%
State	10%	25%
Local	10%	25%

SECTION 9 FY '90

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Operating Assistance LRTA	Improve and maintain fixed route bus service and special services to the elderly and handicapped.	1	Federal State Local Total Activity	1,050 525 525 2,100	LRTA
Capital Assistance LRTA	Bus and bus related facilities Paige Street Transit Center improvements	1	Federal State Local Total Activity	4 .5 .5 5	LRTA
Planning Assistance LRTA	Planning assistance contract with NMAC (To be included in Unified Transportation Planning Work Program)	1	Federal State Local Total Activity	41 10.3 51.3	LRTA
			Federal State Local Total Activity		

$ $ $ $

Federal 75%
State 12.5%
Local 12.5%

SECTION 3 FY '90

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Capital LRTA	Bus and bus related equipment Emergency replacement 22 transit vehicles manufactured by TMC with 40 ft. heavy duty lift equipped transit vehicles	'1	Federal State Local Total Activity	3,300 550 550 4,400	LRTA
			Federal State Local Total Activity		
			Federal State Local Total Activity		
			Federal State Local Total Activity		
			Federal State Local Total Activity		

$ $ $ $

Federal 75%
State 12.5%
Local 12.5%

SECTION 3(a)(1)(C)

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Demonstration Program LRTA	Methanol conversion of diesel buses testing and demonstration program. Conversion kits, fueling facilities, maintenance, training, fuel, etc., for three diesel buses	1	Federal State Local Total Activity	108 18 18 144	LRTA
			Federal State Local Total Activity		
			Federal State Local Total Activity		
			Federal State Local Total Activity		
			Federal State Local Total Activity		

$$$$	Capital	Operating
Federal	80%	50%
State	10%	25%
Local	10%	25%

SECTION 9 FY '91

FE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Operating Assistance LRTA	Improve and maintain fixed route bus service and special services to elderly and handicapped	1	Federal State Local Total Activity	1,100 550 550 2,200	LRTA
Capital Assistance LRTA	Bus and bus related facilities Spare parts	1	Federal State Local Total Activity	40 10 10 50	LRTA
Planning Assistance LRTA	Planning assistance contract with NMAC. (To be included in Unified Transportation Planning Work Program)	1	Federal State Local Total Activity	50 12.5 62.5	LRTA
			Federal State Local Total Activity		
			Federal State Local Total Activity		

PRIVATE SECTOR PARTICIPATION

The LRTA demonstrates a long history of involving the private sector in the provision of LRTA services.

The LRTA has operating contracts with the following private bus operators in this area:

LoLaw Transit Management, Inc.
Leasing Systems Development Corporation
Blanchard Charter Service, Inc./Laidlaw
Ronald H. Rajaniemi Company

These contractors participate actively in the LRTA capital planning process.

The Northern Middlesex Metropolitan Planning Organization (MPO) which includes both the LRTA Advisory Board and the Northern Middlesex Area Commission has adopted a "Private Sector Policy" consistent with UMTA requirements as set forth in the Federal Register October 22, 1984. The policy was formally adopted March 26, 1987.

It is part of this policy to circulate the TIP and all other MPO Certification Documents to "Private Sector" transportation providers in the area. A list of these providers is included at the end of this section. Both the TIP and the UWP have been circulated to this list during the previous fiscal year. There are no new services or service proposals contained in this TIP and therefore no opportunities for increased private sector involvement or proposals to be solicited.

During FY '87, however, in accordance with the UMTA policy of opening existing contracts to competition the LRTA put out to competitive bidding its entire E&H (Road Runner) operation. In addition management services for fixed route operations were competitively bid in the Fall of 1987. During this process no impediments to private sector involvement have been made apparent. No private sector complaints have been received. LRTA is currently operating on five year contracts for fixed route and E&H.

The planning task relating to "Private Sector Involvement" included in the FY 1988 Unified Transportation Planning Work Program (UWP) funded both by UMTA and LRTA has been continued in the FY 1989 UWP.

Private Sector Capital Investment Strategies

The LRTA continues to be active in the planning and development of a public/private joint venture project involving a satellite bus facility/pedestrian access on Authority owned land

immediately adjacent to the Charles A. Gallagher Transportation Terminal. Land acquisition is complete, an RFP for architectural services for the public portion and an RFP for a private developer have been distributed. An architect for the public portion and a developer for the private portion have been selected. The architect for the public portion is under contract with LRTA and a MOU has been signed between LRTA and the private developer preparatory to a contract. Initial site work is complete and contract negotiations with private developer will proceed pending selection of tenants and funding. State environmental approval and funding are pending.

Both public and private interests were represented on the planning committee for this project. The committee was chaired by the director of the Lowell Plan, representing the interests of private sector commercial and industrial enterprises in Lowell. Additional members represent the LRTA, the Chambers of Commerce Northern Middlesex, City of Lowell (City Manager's Office and the Division of Planning and Development) the Commonwealth of Massachusetts Division of Capital Planning and Operations (DCPO). Other resources available to the committee and attending most meetings are the Commonwealth of Massachusetts EOTC, LoLaw Transit Management (LRTA's largest private operator), NMAC, and UMTA. The planning studies that have gone into the preparation of this project are listed on Page 2 of this TIP. At this stage of the project private interests are represented by the private developer, Fryer Group. Biweekly project meetings are conducted between LRTA and Fryer Group to track project progress and develop contractual agreements.

Financial Capacity:

The LRTA reviews its financial capacity annually relative to the availability of Federal funds, State funding, and local assessment. Federal funding involves the availability of UMTA Section 9 apportionments, carryover funding, and funds that may be de-obligated from previous grants for capital, planning and operating assistance. State funding is available to LRTA to match Federal Capital and operating assistance. Additional State "contract assistance" funding is available from time to time primarily for assistance to capital projects. Member communities are assessed for local share based on service received. The level of assessment to member communities is limited to increase only 2.5% per year under Massachusetts' Proposition 2 1/2. Local assessments are used to match Federal capital and operating funds. The Northern Middlesex Area Commission (NMAC) provides local match for planning activities in which it participates.

The present LRTA Administration, which started in 1983, has instituted an improved program of monitoring capital and operating expenses through monthly status reports. Additional projections and analysis are done at the time of budget prepara-

tion. As a result, LRTA has been able to keep operating expenses within Proposition 2 1/2 and to reduce the amount that needs to be borrowed in anticipation of revenues. Borrowing has been cut from $3,600,000 in FY '82 to $2,500,000 in FY '88. The savings in interest through this sound fiscal management have been substantial. An additional benefit to this strong financial position has been aggressive bidding by banks for this borrowing, resulting in improved interest rates.

The $1.34 million of federal money is leveraging $1.34 of State EOTC Capital Assistance Program money, $540,000 local share, $380,000 private contributions, 2.5 million MBTA Bond Issue money and $2.5 million Mass Off-Street Parking money for a total of 8.6 million for the public portion of the project which will generate an additional $8.2 million of private investment.

This public/private partnership will, in turn, generate an estimated $250,000 in revenue annually for LRTA to the direct benefit of local transit operations. In addition, a second phase involving $14 million in private capital and basically no investment by LRTA, is in the preliminary planning stage. This project will also result in additional revenue to LRTA and MBTA from air rights lease payments.

Because of this revenue generation potential the project is viewed as a positive investment in the future by LRTA. Federal capital and operating revenues will be stretched tight during the next two years but not to the point of affecting service. Upon completion, however, the revenue generated by the private portion of the project will permit LRTA to maintain its present level of service in the face of potentially declining operating subsidies.

Private Transportation Providers Operating in LRTA Service Area

Bus Lines

Provider	Address	Telephone
Marinel Transportation	15 Pevey Street, Lowell	458-3316
	Ward Way, North Chelmsford	251-4901
Sullivan Bus Company	356 Littleton Road, Westford	692-3131
Trombly Motor Coach	Route 125, North Andover	686-9703
Hudson Bus Lines	16 Pond Street, Nashua	649-6061
Trailways Bus System**	101 Thorndike St., Lowell	459-7101
Vermont Transit**	101 Thorndike St., Lowell	459-7101
Leasing Systems Development Corporation*	391 School Street, Lowell	475-4310
Chelmsford Council on Aging*	15 Mill Road, Chelmsford	256-0013
Dracut Council on Aging*	951 Mammoth Road, Dracut	957-2611
Tyngsborough Council on Aging*	Lakeview Avenue, Tyngsborough	649-9211
Rajaniemi, Inc.*	368 Main Street, Townsend	597-2687
LoLaw Transit Management, Inc.*	Clark Road, Tewksbury	452-6161
Hillcrest Wheel Chair Service	P.O. Box 165, Dracut	947-5109
Bay State Ambulance & Wheelchair Service	154 Moody Street, Lowell	458-6321
Laidlaw Transit	58 Union Street, Methuen	683-7034
Handi-Van	40 Perry Street, Lowell	453-4317
Pierce Transit	441 Textile Avenue, Dracut	957-2016
McGinn Bus Company	36-38 Alley Street, Lynn	592-0100

Charters/Rentals

Andover-Lowell Mr. Rent-A-Car Van Service**	650 Rogers Street, Lowell	454-0760
Bedford Charter Service**	11 Railroad Avenue, Bedford	275-9524
Shaughnessy FL, Inc.**	489 Boston Road, Billerica	667-8244
Buckingham Bus Service	Station Avenue, Groton	448-6057
Fiore Bus Service	1480 Broadway, Dracut	453-1932
Blanchard Transit Service	555 Whipple Road, Tewksbury	851-9863
Dunbar Bus Company	Tyngsborough, MA	251-7445
S&S of New England, Inc.	716 Middlesex Street, Lowell	454-8073
Sabrina Company	2178 Bridge Street, Dracut	441-0200

* Under contractual agreement with LRTA

** Sent only letter detailing policies regarding private agencies and transit. Documents will be sent upon request.

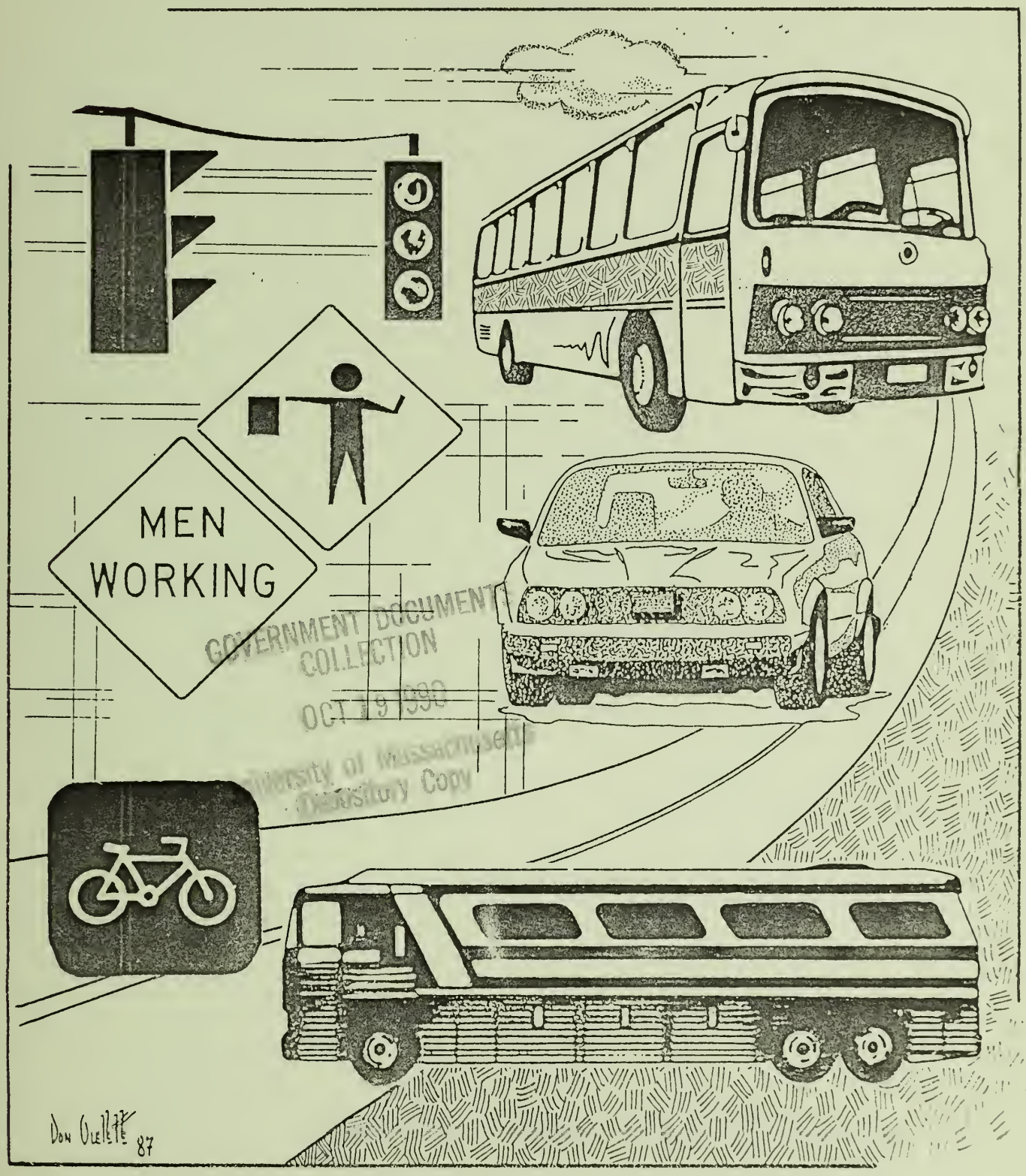
Taxi Service

Provider	Address	Telephone
Community Cab	117 Main Street, Pepperell	433-9944
Harlow Cab	19 West Street, Pepperell	433-8370
A&L Taxi	115 Congress, Lowell	454-5661
Diamond Yellow Cab	50 Payne Street, Lowell	458-6861
Chelmsford Town Taxi	North Chelmsford	251-8858
Fred's Taxi	42 Crimson Road, Billerica	667-2300
Billerica Taxi	1 Edgbaston Street, Billerica	663-8222
TWC Limo and Taxi	33 Nabnasset Street, Westford	692-8880
American Taxi	75 Great Road, Acton	263-7467

MASS. Y3.NMM1:1/3/991

Transportation Improvement Program

Fiscal Year 1991



GOVERNMENT DOCUMENT
COLLECTION
OCT 19 1990
University of Massachusetts
Depository Copy

prepared by: Northern Middlesex Metropolitan Planning Organization

NORTHERN MIDDLESEX

METROPOLITAN PLANNING ORGANIZATION

TRANSPORTATION IMPROVEMENT PROGRAM

FISCAL YEAR 1991

OCTOBER 1, 1990 - SEPTEMBER 30, 1991

This report was completed by NMAC under Intergovernmental Service Agreement #5609 with the Massachusetts Department of Public Works, in cooperation with the Federal Highway Administration and was financed in part through Contract No. MA-08-0167 with the Urban Mass Transportation Adminstration.

[awga-iha.b-r]

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CERTIFICATION OF 3C TRANSPORTATION PLANNING PROCESS

In accordance with the FHWA/UMTA Urban Transportation Planning Final Rule, dated June 30, 1983, the Metropolitan Planning Organization (MPO) for the Northern Middlesex Urbanized Area has completed its review and hereby certifies that the conduct of the 3C Transportation Planning Process complies with the requirements of CFR 450.114 (c); and that said process includes activities to support the development and implementation of this Transportation Improvement Program (TIP), the Transportation Plan, and subsequent project development activities, as necessary and to the degree appropriate.

CERTIFICATION OF PRIVATE ENTERPRISE PARTICIPATION TRANSPORTATION PLANNING PROCESS

The Metropolitan Planning Organization (MPO) for the Northern Middlesex Urbanized Area hereby certifies that the local process for the involvement of the private sector in the transportation planning activity has been followed.

INTRODUCTION

Based on regulations promulgated by the Department of Transportation (DOT), any transportation project funded through the Federal Highway Administration (FHWA) or the Urban Mass Transportation Administration (UMTA) must be listed in the appropriate region's Transportation Improvement Program (TIP). Without such a listing, Federal Highway funds cannot be expended by the Massachusetts Department of Public Works (MDPW) on local or State projects. Similarly, the Lowell Regional Transit Authority (LRTA) can only receive Federal funds for projects listed in the TIP of the Northern Middlesex Metropolitan Planning Organization.

The principal object of this mandatory TIP listing is the provision of an additional point for public access to and review of the transportation planning process.

TIP Organization

The TIP divides projects between two time frames; the Annual Element (AE) and the Future Element (FE). Listed on the Annual Element are all the projects proposed for implementation in the current fiscal year. All other projects are generally considered to be not more than four years distant from entering the Annual Element and are thus listed in the Future Element.

Each element is subdivided so as to list separately individual projects under their appropriate funding category. Projects within each funding category are ranked by NMAC member community officials and citizens according to the locally perceived value of a project meeting regional transportation needs. This priority ranking is non-binding on the MDPW project implementation scheduling process. The ranking does, however, provide the MDPW with important local input regarding the relative value of individual projects within a given funding category.

TIP Development Process

The TIP is a requirement of the Federally mandated transportation planning process. This process is carried out under the authority of the Northern Middlesex Metropolitan Planning Organization (NMMPO) which reviews and endorses all required documents, and consists of: the Chairman of the Northern Middlesex Area Commission (NMAC), the Chairman of the Lowell Regional Transit Authority (LRTA), the Secretary of the Massachusetts Executive Office of Transportation and Construction (EOTC) and the Commissioner of the Massachusetts Department of Public Works (MDPW). The staff of NMAC acts as planning staff to the NMMPO. Under this arrangement NMAC produced the current TIP. The TIP is based on projects listed in the preceding year's TIP updated with current project listings provided by NMAC member

communities, the LRTA, and the MDPW. Priorities for each Annual Element project are suggested by NMAC staff, and submitted to member communities for their review. Following local review, the TIP is submitted to the NMMPO signatories for their official endorsement. Local review includes distribution of the draft document to private transit providers in the area according to NMAC Private Sector Involvement Policy.

As NMAC is the official areawide clearinghouse for Intergovernmental Review under Executive Order 12372, NMAC's endorsement of the TIP represents regional approval under the Federal Project Review System for all projects listed on the current TIP's Annual Element. This review also satisfies Statewide Intergovernmental Review requirements as set forth by Executive Office of Communities and Development Memorandum of July 18, 1986.

TIP Relationship to NMAC Comprehensive Transportation Plan

The Comprehensive Transportation Plan (CTP) covers a period of five to ten years and is updated as needed. The overall transportation goals and policies articulated in the CTP ensure that individual projects are considered within the context of established regional goals, as required by Federal regulation.

The TIP provides access to the funding necessary to transform the CTP's policies and goals into finalized projects. Many TIP Annual Element projects are drawn directly from the CTP. In addition to being drawn from the CTP, transit projects may be derived from special studies and routine capital equipment replacement schedules. The Gallagher Terminal addition (expansion of Gallagher Terminal to include a satellite bus facility and improved pedestrian access) is an example of this process. Special studies have included Development and Use Potential of the Gallagher Terminal, An Overview, NMAC, Fall 1981, LRTA Proposed Satellite Bus Facility and Pedestrian Access on Land Adjacent to Gallagher Terminal, NMAC, September 1984, Feasibility Study: Charles A. Gallagher Transportation Terminal Expansion, Satellite Facility/Pedestrian Access, NMAC, October 1987, Office Market Opportunities, Gallagher Transportation Terminal Site, Hammer Siler George Associates, Parking Analysis Charles A. Gallagher Transportation Terminal Expansion, NMAC, 1989.

TIP Position in Project Funding Sequence

Perhaps one of the most common misconceptions regarding highway project funding involves the relationship between project listing on the TIP and the assurance of funding for project construction.

The fact is that a highway project listing on the TIP does not in any way constitute a financial commitment to construct a

given project. Rather, TIP listing is simply, but importantly, one more step in the implementation process. This process requires, by regulation, that to be funded for construction, all projects must be listed on the TIP Annual Element. However, not all projects listed on the TIP must be funded for construction. In practice during any given year, more projects are listed in the Annual Element than there are available construction funds.

Deciding which projects are funded is the responsibility of the MDPW. Some of the criteria applied in this decision making process are regional priority, project cost, length of construction period and how a given project's completion affects the MDPW's overall transportation system improvement program.

Transit projects are also placed on the TIP prior to and as a necessary condition for commitment of funds by the Urban Mass Transportation Administration (UMTA). The LRTA includes the projects in the Annual Element on its annual Section 9, or other funding program, grant applications to UMTA. Actual funding is then determined by UMTA based on available funds and justification for the projects included in the grant application. As with highway projects, more projects may be programmed on the TIP than annual UMTA apportionments can accommodate. In these cases final priorities are set at the time grant applications are filed and alternate funding avenues or methods are sought through the LRTA's ongoing financial planning activities.

TIP AIR QUALITY ANALYSIS/CONSISTENCY STATEMENT

Introduction

To ensure that projects originating through the transportation planning process in the NMAC region are consistent with the State Implementation Plan (SIP) for air quality, an analysis of the Transportation Improvement Program (TIP) is required. This analysis is mandated only for those projects listed on the TIP Annual Element.

Within the Annual Element two main categories of projects require analysis: those which will affect existing vehicular speed, delay or usage, and those projects which are termed major action projects.

Projects in the first category are analyzed because of their bearing on the relationship between engine operation and mobile source (vehicular) pollution.

Engine Operation and Pollution

Briefly put, every time a vehicle engine is operated, it produces some degree of pollution. The degree of pollution is a function of engine operation as measured by speed in miles per hour (MPH). Generally, as vehicle speed (MPH) increases, engine pollution decreases. Consequently, the larger the percentage increase in speed, the greater the reduction in pollutants. Thus a 5 MPH increase from 30 MPH to 35 MPH produces a larger absolute emission reduction than a 5 MPH increase from 50 MPH to 55 MPH.

Projects Which Change Speed, Delay, Usage:

- Speed - Generally (though not exclusively), projects which increase the operating speeds of a given roadway do so by increasing its capacity. Increased capacity - the ability of a roadway to accommodate more vehicles at one time - results from widening the existing roadway. Thus projects which involve widening a roadway are analyzed.

- Delay - Because there is no clean phase of engine operation, engine idling, termed vehicle delay or simply delay, is a significant contributing factor to mobile source pollution. Typically, signalization projects have a direct bearing on the amount of delay at a given location. For that reason, signalization projects on the Annual Element are analyzed.

- Usage - Because once in operation a vehicle engine is constantly producing pollution, any project which influences the amount of vehicle usage has a direct

impact on air quality. Therefore, projects such as park and ride lots and new transit service which influence use are analyzed.

Major Action Projects

The second category of projects included in this analysis are those which, due to project nature and/or scope, require, by law, that an Environmental Impact Statement (EIS), Environmental Impact Review (EIR) or Finding of No Significant Impact (FONSI) be conducted. These studies document a given project's impact on various systems and elements one of which is air quality.

This consistency analysis takes note of all major action projects listed on the Annual Element. Following completion of these projects' respective reports, NMAC will examine the appropriate air quality data and include it in this analysis. Each annual project which fulfills any of the above definitions is labeled as having Air Quality Significance in its TIP project description.

Methodology

Each project analysis utilizes the methodology developed by the DEQE and MDPW and endorsed by the Air Quality Task Force. Within each analysis the following factors were employed:

- ADT - Existing ADT is factored from base year data to the appropriate study year.
- Emission factors - all factors are from EPA Mobile II.
- 1987 emission factors are adjusted annually using the .86 adjustment factor to reflect 1990 conditions as suggested by DEQE in its August 31, 1987 memo on TIP Analysis Technical Guidance.
- Default noncatalytic/cold/hot start of 20.6%/27.3%/ 20.6%.
- 75° F ambient temperature.
- All emission totals expressed in kilograms. Note 453.7 grams = 1 pound while 1,000 grams = 1 kilogram.

The results of the analysis described above are illustrated in Table 1.

TABLE 1

NMAC FY 1991 TIP A.E. AIR QUALITY FINDINGS

Community	Project	Funding Category Cost	Change in Non-Methane Hydrocarbon Per Ozone Season* 1990
Billerica	Route 3A Signalization Projects	Urban Systems Statewide $1,250,000.	+89.71 kg
Westford	Route 110/ Minott's Corner	Rural Secondary $1,500,000.	+10.31 kg

Conclusion

This analysis of the NMAC FY 1991 TIP reveals that the two signal improvement projects proposed for Route 3A in Billerica and the Minott's Corner improvements in Westford have the potential to increase non-methane hydrocarbons by 100.2 kg in 1991.

* Ozone Season = 180 days

DESCRIPTION OF FUNDING CATEGORIES

The explanations which follow outline the basic uses and requirements of each funding category utilized in this TIP. Specific information related to a particular roadway's eligibility for these funds can be provided by NMAC (454-8021) or the MDPW District 4 Office (648-6100). Questions regarding UMTA funding are best directed to the LRTA (459-0164).

Highway Funding

o Interstate - Finances construction projects on the Interstate System regardless of the urban or rural nature of a project's location. The NMAC region has sections of two operating Interstate facilities, I-495 and I-93, within its boundaries.

Funding: Federal 90%/State 10%.

o Interstate Resurfacing, Restoration, Rehabilitation and Reconstruction (I-4R) - Contributes to financing the major maintenance requirements of the Interstate System.

Funding: Federal 90%/State 10%.

o Urban Systems - Finances construction and maintenance projects on Urban System roadways such as the Middlesex Turnpike and the Lowell Connector. Typically, Urban System facilities are owned by local communities and are high traffic volume arterials or collectors situated in urban areas. For highway planning purposes, the MDPW designates which sections of the highway network are urban or rural.

Funding: Federal 75%/State 25%/Local 100% of design costs.

o Consolidated Primary - Finances construction and maintenance projects on roadways such as Route 3, which are usually rural arterials inclusive of their urban extensions. Again the MDPW (with the approval of DOT) establishes which roads make up the Primary System. Generally, the entire Primary System is State owned.

Funding: Federal 75%/State 25%.

o Rural Secondary - Finances construction and maintenance projects on roadways such as Route 113 in Dunstable which are major collector routes located in areas deemed rural by the MDPW.

Funding: Federal 75%/State 25%.

o Highway Bridge Replacement and Rehabilitation - Finances the replacement or maintenance of deficient bridges without concern for a given bridge's urban or rural setting. Uniquely, these funds may be expended on any highway bridge situated on a public road whether on or off the Federal Aid System. Projects such as replacement of the School Street Bridge in Lowell and the High Street Bridge in Billerica qualify for this category.

Funding: Federal 80%/State 20%.

o Public Works Economic Development (PWED) - Finances roadway projects (such as construction of access roads) which will directly encourage the economic development of the surrounding area.

Funding: Program does not specify amounts of matching funds.

o Rail Highway Crossings Program - Finances projects which eliminate hazards at railroad highway crossings, again regardless of the urban or rural character of a project's location. Typically, projects which meet this category's requirements are grade separations and the installation of flashing lights or gates or signs at rail-highway crossings.

Funding: Federal 90%/State 10%.

o Safer Off-Systems - Finances projects to upgrade and reconstruct non-toll publicly owned roads in both urban and rural areas not on the Federal Aid System.

Funding: Federal 75%/State 25%.

o State Aid - Bikeways - Finances the design, construction or reconstruction of bicycle paths, lanes or routes in either an urban or rural area.

Funding: State 75%/Local 25%, which may be provided through in-kind services.

Transit Funding

o Section Nine (UMTA) - Finances capital, planning and operating expenses for LRTA urban service areas. Section 9 funds are awarded and administered by UMTA.

Funding for capital expenses: Federal 80%/State 10%/ LRTA 10%.

Funding for planning expenses: Federal 80%/NMAC 20%.

Funding for operations expenses: Federal 50%/State 25%/ LRTA 25%.

o Section 18 (UMTA) - Finances capital and operating expenses for transit operations in rural areas. In Massachusetts, this section is administered by the Executive Office of Transportation and Construction (EOTC).

Funding for operating expenses: Federal 50%/State 25%/ LRTA 25%.

Funding for capital expenses: Federal 80%/State 10%/ LRTA 10%.

o Section 16(b) (2) (UMTA) - Finances capital expenses for private non-profit organizations to provide specialized transit services for the elderly and handicapped populations. These awards are approved on a project by project basis, funding only capital expenses for the acquisition of specific types of vans and base station equipment. Section 16(b) (2) does not fund operating expenses under any conditions.

Funding: Federal 80%. Private non-profit organization 20% paid in cash with non-Federal funds.

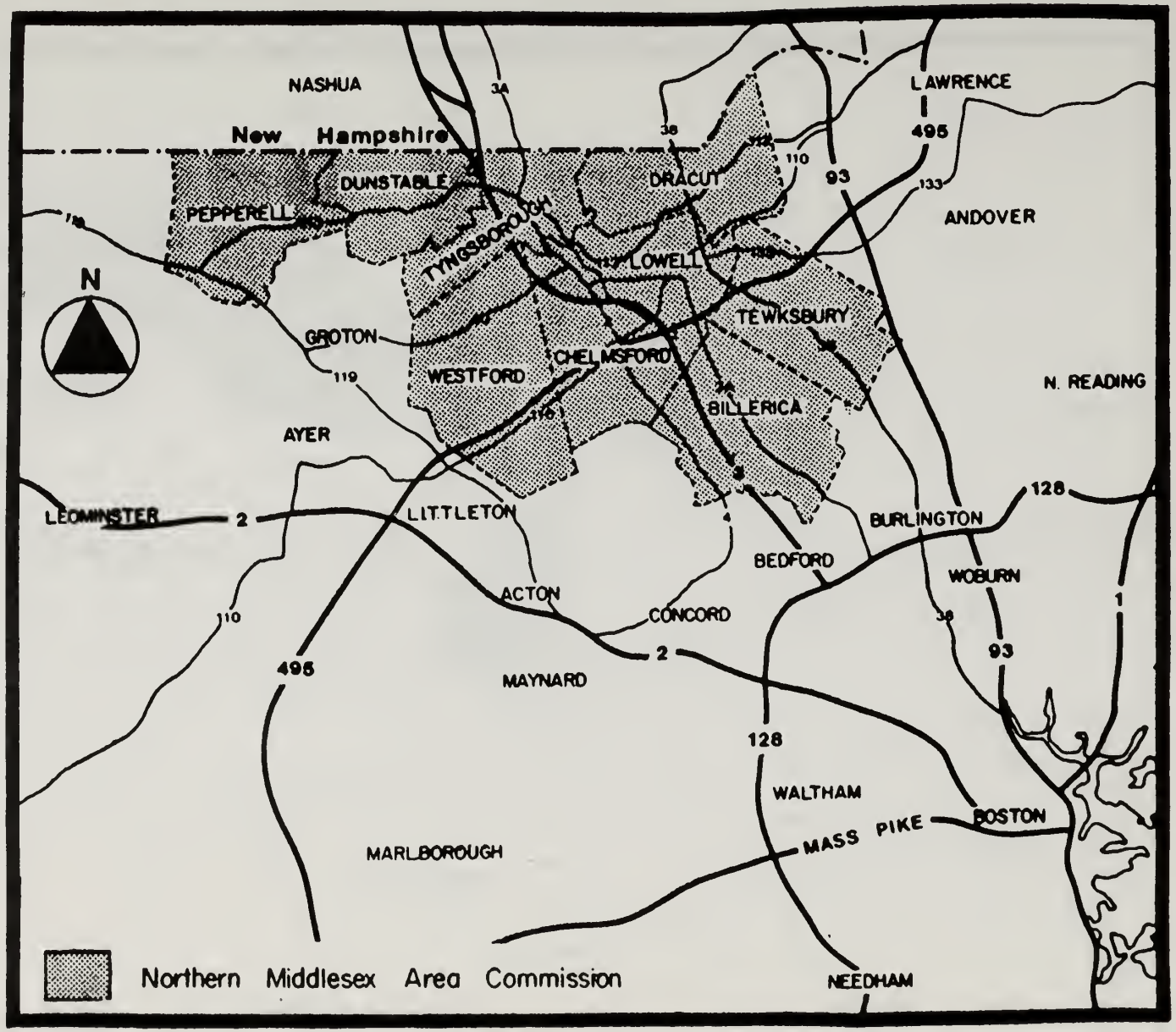
Annual Element Project Totals (Highway)

Table 2 shows the total annual element project costs by funding category. Estimated funding for FY '91 is not yet available, however, based on past years' available funding levels, many funding categories for NMAC TIP project totals would use a large percentage of funds available statewide. This fact points to the extremely competitive nature that exists in funding highway projects.

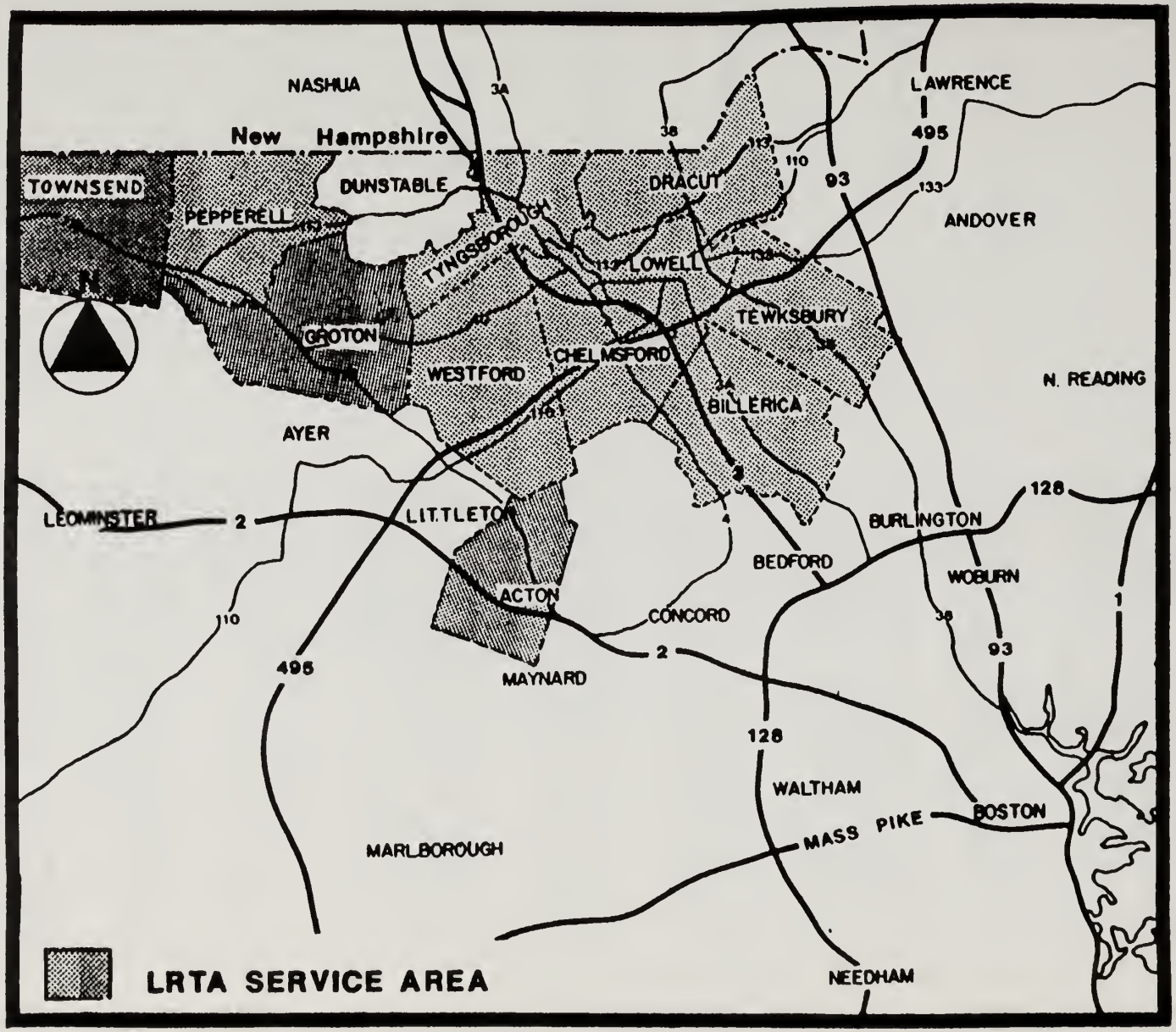
TABLE 2

Category	Annual Element Project Totals
Urban Systems	$1,250,000.
Urban Systems Boston	3,200,000.
Highway Bridge Replacement and Rehabilitation	9,300,000.
Interstate Resurfacing	3,000,000.
Rural Secondary	870,000.
Consolidated Primary	4,500,000.
Hazard Elimination	340,000.

NORTHERN MIDDLESEX AREA COMMISSION REGION



LOWELL REGIONAL TRANSIT AUTHORITY SERVICE AREA



LEXICON

The terms defined below are used throughout the Transportation Improvement Program (TIP).

Activity -	Proposal, planning, engineering (PE), right of way (ROW) or construction (CON) as appropriate for a given project's status.
Air Quality Significance (AQS) -	Indicates a project which influences vehicle speed, delay or usage. (Pg.6)
Annual Element (AE) -	TIP section listing projects proposed for implementation during the current Federal fiscal year (October 1st to September 30th). (Pg. 1)
Future Element (FE) -	TIP section listing projects expected to enter the AE within the next four fiscal years.
Implementing Agency -	Identifies agency or agencies responsible for a project's planning, design and construction.
Regional Priority -	Project ranking approved by NMAC communities and endorsed by the Committee of Signatories (Pg. 1); 1-High; 2-Medium; 3-Low.
Source of Funds -	Level of government(s) - Federal, State, Local - financing a project's implementation.
"T" -	"T" notes a project contained in the current Comprehensive Transportation Plan.
TSM -	Notes a project which employs Transportation System Management (TSM) methods to solve a transportation problem.

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$$$$$$

Federal 75%

State 25%

Local 100% of design costs for locally owned facilities

AE

URBAN SYSTEMS STATEWIDE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Boston Road/ Route 3A Billerica	Traffic signals at Boston Road and Treble Cove Road, Boston Road and Bridge Street, Boston Road and Webb Brook Road (Design work complete) Project I.D.#: 006820	1	Federal	937.5	PE by Town
			State	312.5	CON by MDPW
A.Q.S.			Local	____	
T			Total	1250	
			Activity	CON	

$$$$$$

Federal	75%	URBAN SYSTEMS BOSTON
State	25%	URBANIZED AREA
Local		

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Billerica, Burlington, Bedford	Reconstruction of Crosby Drive and Middlesex Turnpike from the Intersection of Route 62 to Manning Road Project I.D. #029490	2	Federal	2400	MDPW
			State	800	
			Local	____	
			Total	3200	
			Activity	CON	

$$$$$$

Federal 80%

State 20% BRIDGE REPLACEMENT/REHABILITATION

Local

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Bridges in NMAC communities	Necessary preliminary engineering/design as bridges require in NMAC communities		Federal	160	MDPW
			State	40	
			Local	____	
			Total	200	
			Activity	PE	
School Street Bridge, Lowell L-15-22	Design work for rehabilitation of School Street Bridge over Northern Canal Project I.D. #127750	2	Federal	160	MDPW
			State	40	
T			Local	____	
			Total	200	
			Activity	DESIGN	
Plain Street Bridge, Lowell L-15-2	Design work for rehabilitation of Plain Street Bridge over ConRail tracks Project I.D.#: 056550	1	Federal	80	MDPW
			State	20	
T			Local	____	
			Total	100	
			Activity	DESIGN	

$$$$$$

Federal 80%

State 20% BRIDGE REPLACEMENT/REHABILITATION

Local

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Main Street Bridge Tewksbury T-3-8	Reconstruction of Main Street Bridge over B&M Railroad	1	Federal	890.4	MDPW
	Project I.D.#: 042230		State	222.6	
			Local	____	
T			Total	1113	
			Activity	CON	
Gray Street Bridge Billerica B-12-12	Design work for total bridge replacement.	1	Federal	80	MDPW
	Project I.D.#: 029449		State	20	
			Local	____	
T			Total	100	
			Activity	DESIGN	
Andover Road Bridge Billerica B-12-13	Design work for total bridge replacement.	1	Federal	80	MDPW
	Project I.D.#: 002001		State	20	
			Local	____	
T			Total	100	
			Activity	DESIGN	
Pollard Street Bridge Billerica B-12-5	Design work for bridge reconstruction	2	Federal	144	MDPW
	Project I.D.#: 058020		State	36	
			Local	____	
T			Total	180	
			Activity	DESIGN	

$$$$$$

Federal 80%

State 20% BRIDGE REPLACEMENT/REHABILITATION

Local

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Phineas Street Bridge Dracut D-11-5	Design for replacement of existing bridge and related approach roadway. Project I.D.#: 021110	1	Federal	96	MDPW
			State	24	
T			Local	____	
			Total	120	
			Activity	DESIGN	
Brown Street Bridge Billerica B-12-14	Design work for bridge replacement Project I.D.#: 009549	1	Federal	80	MDPW
			State	20	
T			Local	____	
			Total	100	
			Activity	DESIGN	
School Street Bridge Lowell L-15-10	Replace School Street Bridge over railroad tracks and canal Project I.D.#: 127751	1	Federal	3600	MDPW
			State	900	
T			Local	____	
			Total	4500	
			Activity	CON	
River Street Bridge Westford W-26-10	Design work. Replace River Street Bridge over B&M railroad Project I.D.#: 060950	1	Federal	80	MDPW
			State	20	
			Local	____	
			Total	100	
			Activity	DESIGN	

$$$$$$

Federal 80%

State 20% BRIDGE REPLACEMENT/REHABILITATION

Local

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Concord Road Bridge Billerica B-12-21	Replace Bridge Deck on Concord Road Bridge Over Route 3 Project I.D. #: 016430	1	Federal	720	MDPW
			State	180	
			Local	____	
			Total	900	
			Activity	RECON	
Pollard Street Bridge Billerica B-12-5	Bridge reconstruction Project I.D. #: 058020	2	Federal	1440	MDPW
			State	360	
			Local	____	
			Total	1800	
			Activity	RECON	

T

$$$$$$

Federal 90%

State 10%

Local

INTERSTATE RESURFACING (4R)

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
I-495 Westford	Resurface I-495 from Chelmsford/ Westford Town line to Littleton/ Boxborough Town line Project I.D.#: 066162	1	Federal	2700	MDPW
			State	300	
			Local	____	
			Total	3000	
			Activity	RESUR	

$$$$$$

Federal 75%

State 25%

Local

RURAL SECONDARY

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Route 110/ Minott's Corner Westford	Traffic and intersection improvements, including signalization of Minott's Corner Project I.D.#: 080650	1	Federal	667.5	PE by Town
			State	222.5	CON by MDPW
			Local	_____	
			Total	890	
			Activity	CON	

$$$$$$

Federal 75%

State 25% CONSOLIDATED PRIMARY

Local

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Route 3 Chelmsford, Westford, Tyngsborough	Resurface from Route 4 interchange (Drum Hill Rotary) to the New Hampshire State line Project I.D. #: 108570	1	Federal	2625	MDPW
			State	875	
			Local	____	
			Total	3500	
			Activity	RESUR	
I-495 Lowell, Chelmsford	Joint replacement on four bridges: L-15-65, L-15-81, L-15-85, C-8-30 Project I.D. #: 068610	1	Federal	900	MDPW
			State	100	
			Local	____	
			Total	1000	
			Activity	CON	

AE

$$$$$$

Federal 90%

State 10% HAZARD ELIMINATION

Local

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Aiken Street and VFW Highway	Signal upgrade and intersection improvements Project I.D.#: 025705	1	Federal	306	Design by Billerica Plan
			State	34	
			Local	____	CON by MDPW
			Total	340	
			Activity	CON	

$$$$$$

Federal 75%

State 25%

Local

URBAN SYSTEMS BOSTON

URBANIZED AREA

FE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Billerica, Bedford, Burlington	Phase II - Reconstruction of Crosby Drive and Middlesex Turnpike: Crosby Drive from Route 62 to Middlesex Turnpike; Middlesex Turnpike from Burlington Town line to Manning Road Project I.D.#: 029491	1	Federal	9375	MDPW
			State	3125	
			Local	____	
			Total	12500	
			Activity	CON	

$$$$$$

Federal 75%

State 25% URBAN SYSTEMS STATEWIDE

Local 100% of design costs for locally owned facilities

FE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Merrimack St., Dutton St., and Arcand Dr. Lowell T	Reconstruction of the intersection of Merrimack Street, Dutton Street, and Arcand Drive (Monument Square) Project I.D.#: 040405	2	Federal State Local Total Activity	525 175 ____ 700 CON	Design by City CON by MDPW
Route 38/ Rogers Street Lowell T	Improvements on Route 38/Rogers Street corridor Project I.D.#: 112180	1	Federal State Local Total Activity	412.5 137.5 ____ 550 CON	PE by Lowell Plan CON by MDPW
Route 129 Chelmsford T	Reconstruction of Route 129 from Alpha Road to Industrial Avenue Project I.D.#: 089003	1	Federal State Local Total Activity	1425 475 ____ 1900 CON	PE by Town CON by MDPW
Thorndike St. Lowell T	Reconstruciton of Thorndike St. from Lowell Connector to the beginning of the Sampson Connector Project I.D.#: 133912	1	Federal State Local Total Activity	600 200 ____ 800 RECON	PE by City CON by MDPW

$$$$$$

Federal 75%

State 25%

Local

RURAL SECONDARY

FE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Route 113 Pepperell T	Channelization of Main Street and Groton Street at Railroad Square Project I.D.#: 081601	2	Federal	375	Preliminary design by Town
			State	125	
			Local	____	
			Total	500	
			Activity	CON	

$$$$$$

Federal 80%

State 20% BRIDGE REPLACEMENT/REHABILITATION

Local

FE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
School Street Bridge Lowell L-15-22	Replace or substantially rehabilitate School Street Bridge over Northern Canal. Project I.D.#: 127750	2	Federal	1600	MDPW
			State	400	
			Local	____	
T			Total	2000	
			Activity	RECON	
Plain Street Bridge, Lowell L-15-2	Replace or substantially rehabilitate Plain Street Bridge over ConRail tracks Project I.D.#: 056550	1	Federal	800	MDPW
			State	200	
			Local	____	
T			Total	1000	
			Activity	RECON	
Gray Street Bridge Billerica B-12-12	Total bridge replacement Project I.D.#: 029449	1	Federal	800	MDPW
			State	200	
			Local	____	
T			Total	1000	
			Activity	RECON	
Andover Road Bridge Billerica B-12-13	Total bridge replacement Project I.D.#: 002001	1	Federal	800	MDPW
			State	200	
			Local	____	
T			Total	1000	
			Activity	RECON	

$$$$$$

Federal 80%

State 20%

Local

BRIDGE REPLACEMENT/REHABILITATION

FE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Aiken Street Bridge, Lowell L-15-20	Bridge reconstruction Project I.D.#: 000910	1	Federal	4000	MDPW
			State	1000	
T			Local	____	
			Total	5000	
			Activity	RECON	
Boylston St. Bridge, Lowell L-15-5	Reconstruction of Boylston bridge over the B&M railroad Project I.D.#: 007105	2	Federal	800	MDPW
			State	200	
T			Local	____	
			Total	1000	
			Activity	RECON	
Permanent river crossing over Merrimack River Lowell	New bridge across Merrimack River including approaches Project I.D.#: 103000	1	Federal	36000	MDPW
			State	9000	
T			Local	____	
			Total	45000	
			Activity	CON	
Phineas Street Bridge Dracut D-11-5	Complete replacement of existing bridge and related approach roadway Project I.D.#: 021110	1	Federal	960	MDPW
			State	240	
T			Local	____	
			Total	1200	
			Activity	RECON	

$$$$$$

Federal 80%

State 20%

Local

BRIDGE REPLACEMENT/REHABILITATION

FE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Route 111/119 Bridge Pepperell P-6-1 G-14-5	Reconstruct bridge over Nashua River Project I.D.#: 029910	2	Federal	640	MDPW
			State	160	
			Local	____	
T			Total	800	
			Activity	RECON	
Brown Street Bridge Billerica B-12-14	Total bridge replacement Project I.D.#: 009549	1	Federal	800	MDPW
			State	200	
			Local	____	
T			Total	1000	
			Activity	CON	
Princeton Street (Rte. 3A) Bridge Chelmsford C-8-3	Bridge reconstruction Project I.D.#: 109800	2	Federal	67.5	MDPW
			State	22.5	
			Local	____	
T			Total	90	
			Activity	CON	
River St. Bridge Westford W-26-10	Replace River Street Bridge over B&M Railroad Project I.D.#: 060950	2	Federal	640	MDPW
			State	160	
			Local	____	
			Total	800	
			Activity	CON	

$$$$$$

Federal 90%

State 10%

Local

HAZARD ELIMINATION

FE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Five intersection improvements Lowell T	Signal installations and related geometric improvements at the following five intersections: 1. Aiken Street/Lakeview Avenue 2. Pine Street/Stevens Street 3. Westford Street/Pine Street 4. Westford Street/Stevens St. 5. Aiken Street/W.Sixth Street Project I.D.#: 025705	2	Federal State Local Total Activity	348.3 38.7 ____ 387 PE	MDPW

$$$$$$

Federal 75%

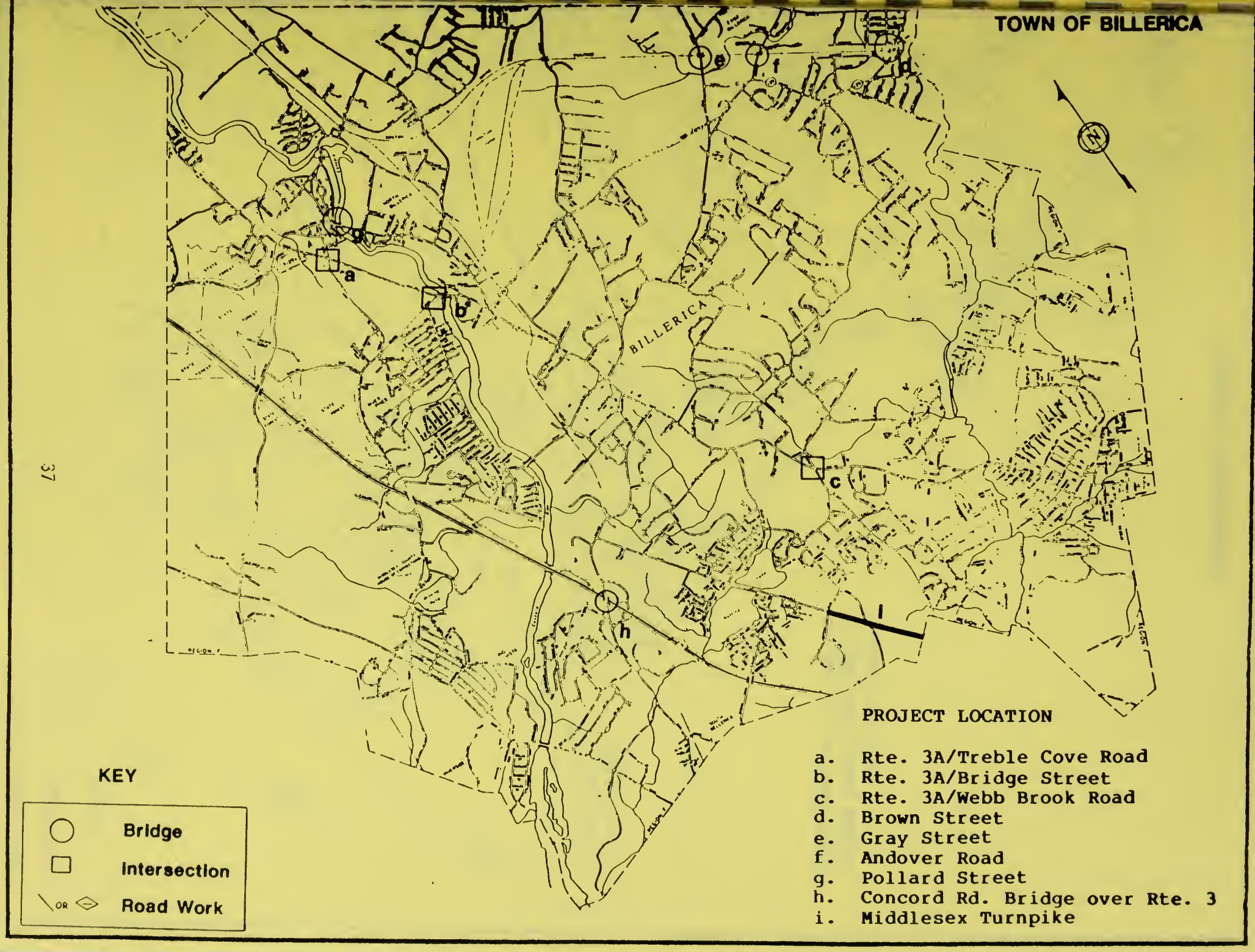
State 25%

Local

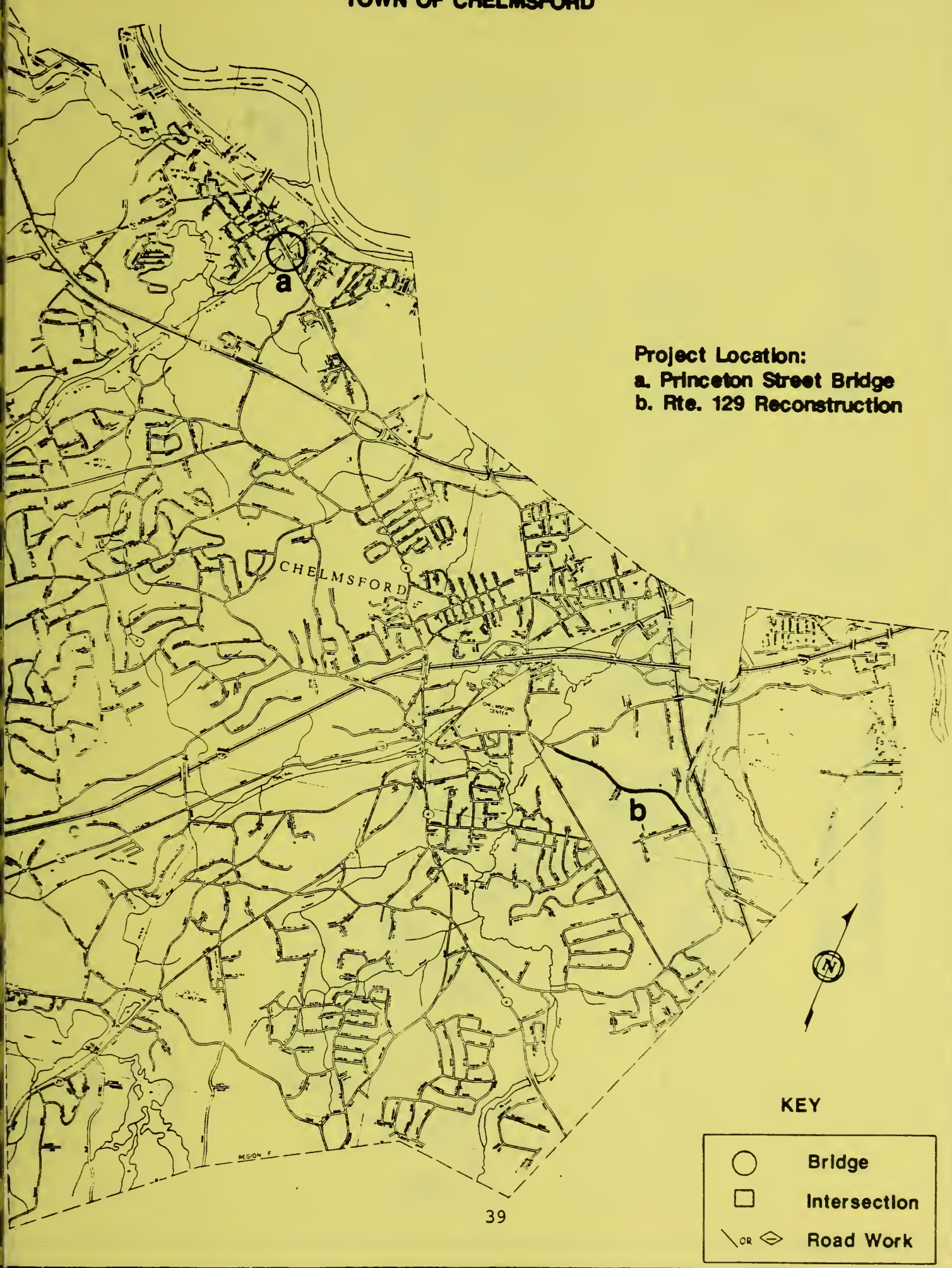
CONSOLIDATED PRIMARY

FE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Route 3 Billerica T	Route 3 widening project Phase I Burlington and Billerica Project I.D.#: 107700	1	Federal	22500	MDPW
			State	7500	
			Local	____	
			Total	30000	
			Activity	CON	
Route 3 Billerica, Lowell, Chelmsford, Westford, Tyngsborough	Route 3 widening Phase II from Billerica to New Hampshire State line Project I.D.#: 107690	1	Federal	22500	MDPW
			State	7500	
			Local	____	
			Total	30000	
			Activity	CON	
I-495 Chelmsford	Lengthen roadside rest areas currently on I-495 Project I.D.#: 066101	1	Federal	225	MDPW
			State	75	
			Local	____	
			Total	300	
			Activity	CON	


TOWN OF BILLERICA
BILLERICA
a
b
c
d
e
f
g
h
i
N
KEY
Bridge
Intersection
Road Work
PROJECT LOCATION
a. Rte. 3A/Treble Cove Road
b. Rte. 3A/Bridge Street
c. Rte. 3A/Webb Brook Road
d. Brown Street
e. Gray Street
f. Andover Road
g. Pollard Street
h. Concord Rd. Bridge over Rte. 3
i. Middlesex Turnpike

TOWN OF CHELMSFORD



Project Location:
a. Princeton Street Bridge
b. Rte. 129 Reconstruction

TOWN OF DRACUT

Project Location:

a. Phineas Street Bridge

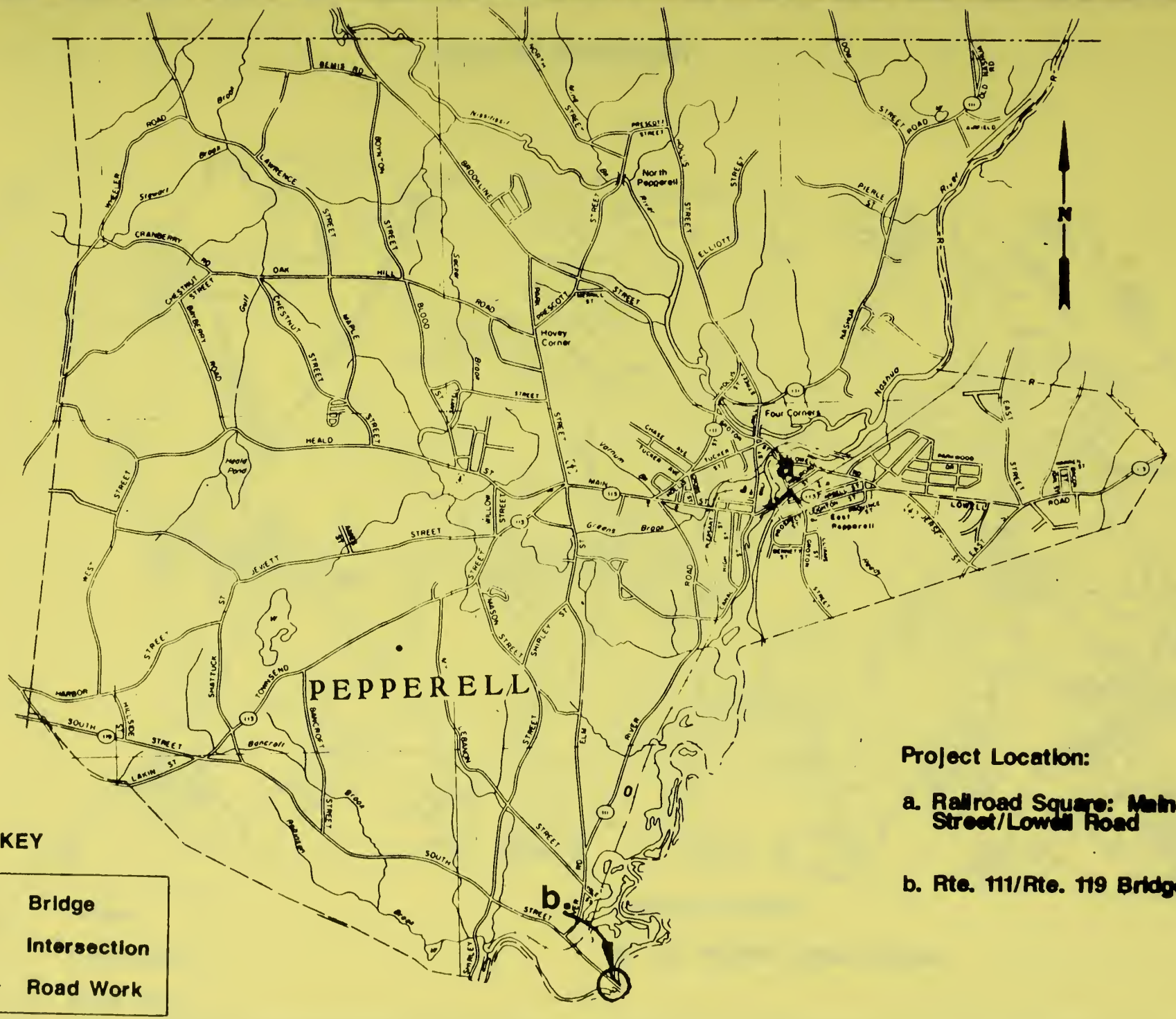
CITY OF LOWELL

PROJECT LOCATION

a. Boylston Street
b. School Street
c. Merrimack, Dutton and Arcand Streets
d. Rte. 38/Rogers Street
e. Thorndike Street
f. School Street
g. Plain Street
h. Aiken Street
i. Aiken Street and Lakeview Avenue
j. Pine Street and Stevens Street
k. Westford Street and Stevens Street
l. Aiken Street and West Sixth Street
m. Westford Street and Pine Street
n. Aiken Street/VFW Highway

KEY

- ○ Bridge
- □ Intersection
- \ OR ◇ Road Work



Project Location:

a. Railroad Square: Main Street/Lowell Road

b. Rte. 111/Rte. 119 Bridge

KEY

- ○ **Bridge**
- □ **Intersection**
- \ OR ◇ **Road Work**

TOWN OF TEWKSBURY

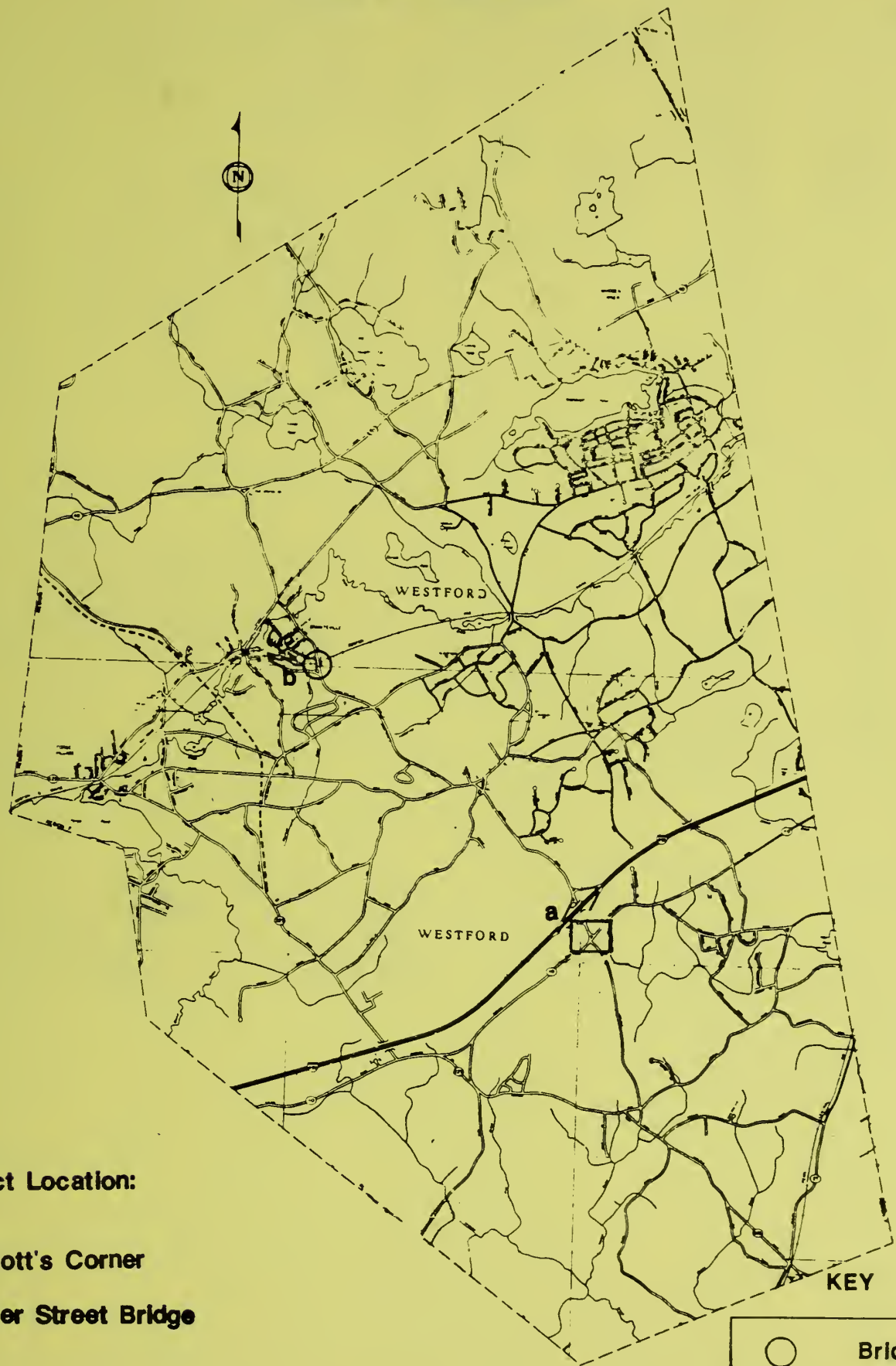
KEY

- Bridge
- Intersection
- Road Work

Project Location:

a. Rte. 38/Main Street Bridge

TOWN OF WESTFORD



Project Location:

a. Minott's Corner

b. River Street Bridge

KEY

- ○ **Bridge**
- □ **Intersection**
- \ OR ◇ **Road Work**

$$$$$$

	Capital	Operating
Federal	80%	50%
State	10%	25%
Local	10%	25%

SECTION 9 FY' 91

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Operating Assistance LRTA	Improve and maintain fixed route bus service and special services to the elderly and handicapped.	1	Federal	998	LRTA
			State	1227	
			Local	771	
			Total	2996	
			Activity		
Capital Assistance LRTA	Bus and bus related facilities Spare parts Supervisory vehicle (LoLaw) Office technology systems (LRTA)	1	Federal	46.7	LRTA
			State	5.8	
			Local	5.8	
			Total	58.3	
			Activity		
Planning Assistance LRTA	Planning assistance contract with NMAC (To be included in Unified Transportation Planning Work Program)	1	Federal	40	LRTA
			State		
			Local	10	
			Total	50	
			Activity		

$$$$$$

Federal	75%
State	12.5%
Local	12.5%

SECTION 3 FY '91

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Capital	Bus and bus related equipment	1	Federal	3300	LRTA
LRTA	Emergency replacement 22 transit vehicles manufactured by TMC with 40 ft. heavy duty lift equipped transit vehicles		State	550	
			Local	550	
			Total	4400	
			Activity		

$$$$$$

Federal	75%
State	12.5%
Local	12.5%

SECTION 3(a)(1)(C)

AE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Demonstration Program LRTA	Methanol conversion of diesel buses testing and demonstration program. Conversion kits, fueling facilities, maintenance, training, fuel, etc., for three diesel buses	1	Federal	108	LRTA
			State	18	
			Local	18	
			Total	144	
			Activity		

$$$$$$

	Capital	Operating
Federal	80%	50%
State	10%	25%
Local	10%	25%

SECTION 9 FY '92

FE

Facility - Community	Project Description	Regional Priority	Source of Funds	Est. Cost (000's)	Implementing Agency
Operating Assistance LRTA	Improve and maintain fixed route bus service and special services to elderly and handicapped	1	Federal	1100	LRTA
			State	550	
			Local	550	
			Total	2200	
			Activity		
Capital Assistance LRTA	Bus and bus related facilities Spare parts	1	Federal	40	LRTA
			State	5	
			Local	5	
			Total	50	
			Activity		
Planning Assistance LRTA	Planning assistance contract with NMAC. (To be included in Unified Transportation Planning Work Program)	1	Federal	40	LRTA
			State		
			Local	10	
			Total	50	
			Activity		

PRIVATE SECTOR PARTICIPATION

The LRTA demonstrates a long history of involving the private sector in the provision of LRTA services.

All LRTA service is contracted to private operators through operating contracts with the following private bus operators:

LoLaw Transit Management, Inc.
Leasing Systems Development Corporation
Blanchard Charter Service, Inc./Laidlaw
Ronald H. Rajaniemi Company

These contractors participate actively in the LRTA capital planning process.

The Northern Middlesex Metropolitan Planning Organization (MPO) which includes both the LRTA Advisory Board and the Northern Middlesex Area Commission has adopted a "Private Sector Policy" consistent with UMTA requirements as set forth in the Federal Register October 22, 1984. The policy was formally adopted March 26, 1987.

It is part of this policy to circulate the TIP and all other MPO Certification Documents to "Private Sector" transportation providers in the area. A list of these providers is included at the end of this section. Both the TIP and the UWP have been circulated to this list during the previous fiscal year. There are no new services or service proposals contained in this TIP and therefore no opportunities for increased private sector involvement or proposals to be solicited.

During FY '87, however, in accordance with the UMTA policy of opening existing contracts to competition the LRTA put out to competitive bidding its entire E&H (Road Runner) operation. In addition management services for fixed route operations were competitively bid in the Fall of 1987. During this process no impediments to private sector involvement have been made apparent. No private sector complaints have been received. LRTA is currently operating on five year contracts for fixed route and E&H.

The planning task relating to "Private Sector Involvement" included in the FY 1989 Unified Transportation Planning Work Program (UWP) funded both by UMTA and LRTA has been continued in the FY 1990 UWP.

Private Sector Capital Investment Strategies

The LRTA continues to be active in the planning and development of a public/private joint venture project involving a satellite bus facility/pedestrian access on Authority owned land

immediately adjacent to the Charles A. Gallagher Transportation Terminal. Land acquisition is complete, an RFP for architectural services for the public portion and an RFP for a private developer have been distributed. An architect for the public portion and a developer for the private portion have been selected. This developer has subsequently withidrawn due to inability to secure tenants and financing. The architect/engineering firm for the public portion is under contract with LRTA and has completed plans and bid specifications for the public portion. Initial site work is complete and the public portion has been bid. State environmental approval and funding are in place. The public portion is proceeding even though the initial private developer withdrew from the process. LRTA has enlisted the help of the Urban Land Institute and is aggressively marketing the site to a broader base of potential clients. Information prepared to date has been forwarded to UMTA.

Both public and private interests were represented on the planning committee for this project. The committee was chaired by the director of the Lowell Plan, representing the interests of private sector commercial and industrial enterprises in Lowell. Additional members represent the LRTA, the Chambers of Commerce Northern Middlesex, City of Lowell (City Manager's Office and the Division of Planning and Development) the Commonwealth of Massachusetts Division of Capital Planning and Operations (DCPO). Other resources available to the committee and attending most meetings are the Commonwealth of Massachusetts EOTC, LoLaw Transit Management (LRTA's largest private operator), NMAC, and UMTA. The planning studies that have gone into the preparation of this project are listed on Page 2 of this TIP.

Financial Capacity:

The LRTA reviews its financial capacity annually relative to the availability of Federal funds, State funding, and local assessment. Federal funding involves the availability of UMTA Section 9 apportionments, carryover funding, and funds that may be de-obligated from previous grants for capital, planning and operating assistance. State funding is available to LRTA to match Federal Capital and operating assistance. Additional State "contract assistance" funding is available from time to time primarily for assistance to capital projects. Member communities are assessed for local share based on service received. The level of assessment to member communities is limited to increase only 2.5% per year under Massachusetts' Proposition 2 1/2. Local assessments are used to match Federal capital and operating funds. The Northern Middlesex Area Commission (NMAC) provides local match for planning activities in which it participates.

The present LRTA Administration, which started in 1983, has instituted an improved program of monitoring capital and operating expenses through monthly status reports. Additional

projections and analysis are done at the time of budget preparation. As a result, LRTA has been able to keep operating expenses within Proposition 2 1/2 and to reduce the amount that needs to be borrowed in anticipation of revenues. Borrowing has been cut from $3,600,000 in FY '82 to $2,500,000 in FY '88. The savings in interest through this sound fiscal management have been substantial. An additional benefit to this strong financial position has been aggressive bidding by banks for this borrowing, resulting in improved interest rates.

For the Gallagher Terminal addition project, $1.34 million of federal money is leveraging $1.34 of State EOTC Capital Assistance Program money, $540,000 local share, $380,000 private contributions, 2.5 million MBTA Bond Issue money and $2.5 million Mass Off-Street Parking money for a total of 8.6 million for the public portion of the project which could generate an additional $8.2 million of private investment.

It is anticipated that when a public/private partnership is negotiated it will generate an estimated $250,000 in revenue annually for LRTA to the direct benefit of local transit operations.

Because of its revenue generation potential this project is viewed as a positive investment in the future by LRTA. Federal capital and operating revenues will be stretched tight during the next two years but not to the point of affecting service. Upon completion, however, the revenue generated by the private portion of the project will permit LRTA to maintain its present level of service in the face of potentially declining operating subsidies.

Private Transportation Providers Operating in LRTA Service Area

Bus Lines

Provider	Address	Telephone
National School Bus	15 Pevey Street, Lowell	458-3316
	Ward Way, North Chelmsford	251-4901
Trombly Motor Coach	1480 Broadway Road, Dracut	453-1932
Hudson Bus Lines	16 Pond Street, Nashua	649-6061
Leasing Systems Development Corporation*	391 School Street, Lowell	475-4310
Chelmsford Council on Aging*	1 North Road, Chelmsford	256-0013
Dracut Council on Aging*	951 Mammoth Road, Dracut	957-2611
Tyngsborough Council on Aging*	Lakeview Avenue, Tyngsborough	649-9211
Rajaniemi, Inc.*	368 Main Street, Townsend	597-2687
LoLaw Transit Management, Inc.*	Clark Road, Tewksbury	452-6161
Hillcrest Wheel Chair Service	P.O. Box 165, Dracut	947-5109
Bay State Ambulance & Wheelchair Service	154 Moody Street, Lowell	458-6321
Laidlaw Transit	58 Union Street, Methuen	683-7034
Handi-Van	40 Perry Street, Lowell	453-4317
Pierce Transit	441 Textile Avenue, Dracut	957-2016
McGinn Bus Company	36-38 Alley Street, Lynn	592-0100
EMT Corp. (Everyday Medical Transportation, Brian Mercer, Pres.)	75 Hillside Avenue, Lawrence	686-1199
Medicar, Inc.	41 Osgood Street, Lowell	459-3848
(Contacts: Marlene Kaplin or Sotheavy Lee)		452-3382
R.C. Herrmann Bus Company	250 Littleton Road, Westford	692-3143
Trailways Bus System**	101 Thorndike St., Lowell	459-7101
Vermont Transit**	101 Thorndike St., Lowell	459-7101
Peter Pan**	101 Thorndike St., Lowell	459-7101

Charters/Rentals

Bedford Charter Service**	11 Railroad Avenue, Bedford	275-9524
Shaughnessy FL, Inc.**	489 Boston Road, Billerica	667-8244
Buckingham Bus Service	Station Avenue, Groton	448-6057
Fiore Bus Service	1480 Broadway, Dracut	453-1932
Blanchard Transit Service	555 Whipple Road, Tewksbury	851-9863
Dunbar Bus Company	Tyngsborough, MA	251-7445

* Under contractual agreement with LRTA
** Sent only letter detailing policies regarding private agencies and transit. Documents will be sent upon request.

Provider	Address	Telephone
S&S of New England, Inc.	716 Middlesex Street, Lowell	454-8073
Sabrina Company	2178 Bridge Street, Dracut	441-0200
A.J. Gagnon & Sons	Gagnon Drive, Dracut	957-3100
Ryder Transportation Service	100 Littleton Road, Westford	692-0232

Taxi Service

Provider	Address	Telephone
Community Cab	117 Main Street, Pepperell	433-9944
Harlow Cab	19 West Street, Pepperell	433-8370
A&L Taxi	115 Congress, Lowell	454-5661
Diamond Yellow Cab	50 Payne Street, Lowell	458-6861
Chelmsford Town Taxi	North Chelmsford	251-8858
Fred's Taxi	42 Crimson Road, Billerica	667-2300
Billerica Taxi	1 Edgbaston Street, Billerica	663-8222
TWC Limo and Taxi	33 Nabnasset Street, Westford	692-8880

MASS. Y3.NMMI: 1/3/993

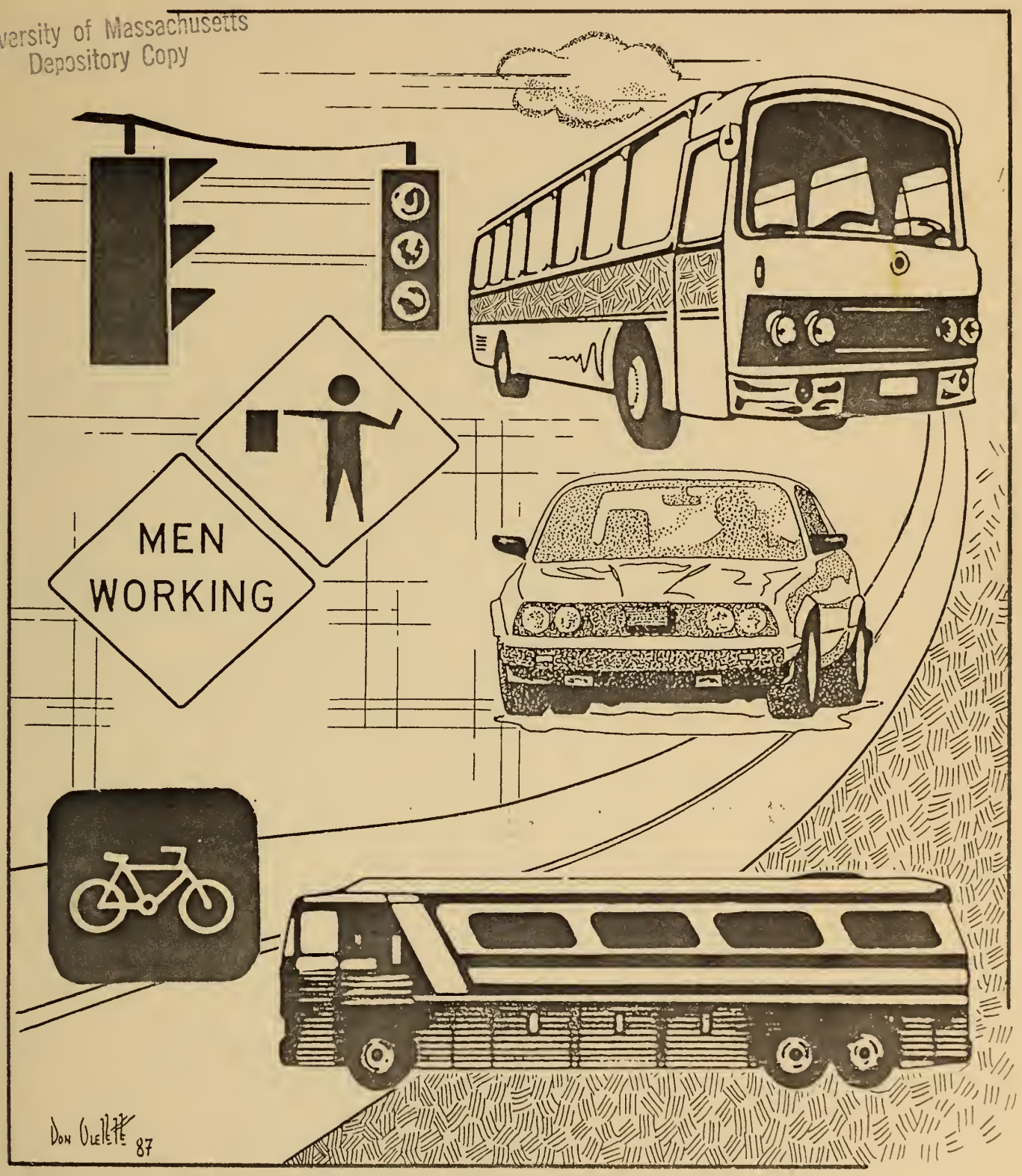
Transportation Improvement Program

GOVERNMENT DOCUMENTS
COLLECTION

MAY 1 7 1993

University of Massachusetts
Depository Copy

FISCAL YEAR 1993



prepared by: Northern Middlesex Metropolitan Planning Organization

NORTHERN MIDDLESEX

METROPOLITAN PLANNING ORGANIZATION

TRANSPORTATION IMPROVEMENT PROGRAM

FISCAL YEAR 1993

OCTOBER 1, 1992 - SEPTEMBER 30, 1993

AS AMENDED NOVEMBER 1992

This report was completed by NMCOG under Intergovernmental Service Agreement #5609 with the Massachusetts Highway Department, in cooperation with the Federal Highway Administration and was financed in part through Contract No. MA-08-0167 with the Federal Transit Administration.

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CERTIFICATION OF 3C TRANSPORTATION PLANNING PROCESS

In accordance with the FHWA/FTA Urban Transportation Planning Final Rule, dated June 30, 1983, the Metropolitan Planning Organization (MPO) for the Northern Middlesex Urbanized Area has completed its review and hereby certifies that the conduct of the 3C Transportation Planning Process complies with the requirements of CFR 450.114 (c); and that said process includes activities to support the development and implementation of this Transportation Improvement Program (TIP), the Transportation Plan, and subsequent project development activities, as necessary and to the degree appropriate.

CERTIFICATION OF PRIVATE ENTERPRISE PARTICIPATION

TRANSPORTATION PLANNING PROCESS

The Metropolitan Planning Organization (MPO) for the Northern Middlesex Urbanized Area hereby certifies that the local process for the involvement of the private sector in the transportation planning activity has been followed.

CERTIFICATION OF AIR QUALITY CONFORMANCE

In accordance with Section 176(c)(3)(A) of the 1990 Clean Air Act Amendments, the Metropolitan Planning Organization for the Northern Middlesex Region has completed its review and hereby certifies that the FY '93 Transportation Improvement Program is in conformance with Section 5 of the Interim Guidance issued in June 1991. This has been demonstrated by finding that the projects, programs and analyses included herein:

1. are consistent with the most recent estimates of mobile source emissions;

2. provide for implementation of transportation control measures (the status of such TCMs is outlined in Appendix A);

3. contribute to annual emission reductions with respect to ozone and carbon monoxide consistent with Section 182(b)(1) and 187(n)(7);

4. conform to the State Implementation Plan's purpose of reducing the severity and number of violations and expeditiously achieving standards;

5. do not cause or contribute to new violations, increase the severity and frequency of existing violations, or delay attainment of the standards or interim emission-reduction targets.

INTRODUCTION

Based on regulations promulgated by the Department of Transportation (DOT), any transportation project funded through the Federal Highway Administration (FHWA) or the Federal Transit Administration (FTA) must be listed in the appropriate region's Transportation Improvement Program (TIP). Without such a listing, Federal highway funds cannot be expended by the Massachusetts Highway Department (MHD) on local or State projects. Similarly, the Lowell Regional Transit Authority (LRTA) can only receive Federal funds for projects listed in the TIP of the Northern Middlesex Metropolitan Planning Organization.

The principal object of this mandatory TIP listing is the provision of an additional point for public access to and review of the transportation planning process.

TIP Organization

The TIP lists projects by fiscal year. The FY 1993 TIP lists all projects proposed for implementation during Fiscal Years 1993-1995.

Each Fiscal Year is subdivided so as to list separately individual projects under their appropriate funding category. Highway and Transit projects are listed in separate sections.

TIP Development Process

The TIP is a requirement of the Federally mandated transportation planning process. This process is carried out under the authority of the Northern Middlesex Metropolitan Planning Organization (NMMPO) which reviews and endorses all required documents, and consists of: the Chairman of the Northern Middlesex Council of Governments (NMCOG), the Chairman of the Lowell Regional Transit Authority (LRTA), the Secretary of the Massachusetts Executive Office of Transportation and Construction (EOTC) and the Commissioner of the Massachusetts Highway Department (MHD). The staff of NMCOG acts as planning staff to the NMMPO. Under this arrangement NMCOG produced the current TIP. The TIP is based on projects listed in the preceding year's TIP updated with current project listings provided by NMCOG member communities, the LRTA, and the MHD. Following local review, the TIP is submitted to the NMMPO signatories for their official endorsement. Local review includes distribution of the draft document to private transit providers in the area according to NMCOG Private Sector Involvement Policy.

As NMCOG is the official areawide clearinghouse for Intergovernmental Review under Executive Order 12372, NMCOG's endorsement of the TIP represents regional approval under the Federal Project Review System for all projects listed on the current TIP.

This review also satisfies Statewide Intergovernmental Review requirements as set forth by Executive Office of Communities and Development Memorandum of July 18, 1986.

TIP Amendment/Adjustment Procedures

For purposes of project selection and programming, any project listed in FY 1993 of the endorsed TIP will be considered to have the concurrence of the MPO without further action required. Prioritization of projects will have taken place by virtue of placement of a project in Fiscal Years 1993-1995 of the TIP.

In order to minimize constraints on programming projects, the endorsed TIP has provisions, as adopted by the MPO, that allow relatively minor adjustments to be made without formal MPO action. Significant changes require MPO action through the amendment process. Minor adjustments may include such actions as moving a project from FY 1994 to FY 1993, and may be accomplished through an agreed-upon administrative action. Major alterations requiring formal MPO action would include significant changes such as the addition of a project not previously stipulated or the advancement of an FY 1995 project.

TIP Relationship to NMCOG Comprehensive Transportation Plan

The Comprehensive Transportation Plan (CTP) covers a period of five to ten years and is updated as needed. The overall transportation goals and policies articulated in the CTP ensure that individual projects are considered within the context of established regional goals, as required by Federal regulation.

The TIP provides access to the funding necessary to transform the CTP's policies and goals into finalized projects. Many TIP projects are drawn directly from the CTP. In addition to being drawn from the CTP, transit projects may be derived from special studies and routine capital equipment replacement schedules. The Gallagher Terminal addition (expansion of Gallagher Terminal to include a satellite bus facility and improved pedestrian access) is an example of this process. Special studies have included *Development and Use Potential of the Gallagher Terminal, An Overview*, NMAC, Fall 1981, *LRTA Proposed Satellite Bus Facility and Pedestrian Access on Land Adjacent to Gallagher Terminal*, NMAC, September 1984, *Feasibility Study: Charles A. Gallagher Transportation Terminal Expansion, Satellite Facility/Pedestrian Access*, NMAC, October 1987, *Office Market Opportunities, Gallagher Transportation Terminal Site*, Hammer Siler George Associates, *Parking Analysis Charles A. Gallagher Transportation Terminal Expansion*, NMAC, 1989.

TIP Position in Project Funding Sequence

Perhaps one of the most common misconceptions regarding highway project funding involves the relationship between project listing on the TIP and the assurance of funding for project construction.

The fact is that a highway project listing on the TIP does not in any way constitute a financial commitment to construct a given project. Rather, TIP listing is simply, but importantly, one more step in the implementation process. This process requires, by regulation, that to be funded for construction, all projects must be listed on the TIP. However, not all projects listed on the TIP must be funded for construction. In practice during any given year, many more projects are listed than there are available construction funds.

Deciding which projects are funded is the responsibility of the MPO. Some of the criteria applied in this decision making process are regional priority, project cost, length of construction period and how a given project's completion affects the overall transportation system improvement program.

Transit projects are also placed on the TIP prior to and as a necessary condition for commitment of funds by the Federal Transit Administration (FTA). The LRTA includes the projects on its annual Section 9, or other funding program, grant applications to FTA. Actual funding is then determined by FTA based on available funds and justification for the projects included in the grant application. As with highway projects, more projects may be programmed on the TIP than annual FTA apportionments can accommodate. In these cases final priorities are set at the time grant applications are filed and alternate funding avenues or methods are sought through the LRTA's ongoing financial planning activities.

TIP AIR QUALITY ANALYSIS/CONFORMANCY STATEMENT

Introduction

To ensure that projects originating through the transportation planning process in the NMCOG region are consistent with the State Implementation Plan (SIP) for air quality, an analysis of the Transportation Improvement Program (TIP) is required.

Within the Transportation Improvement Program two main categories of projects require analysis: those which will affect existing vehicular speed, delay or usage, and those projects which are termed major action projects.

Briefly put, every time a vehicle engine is operated, it produces some degree of pollution. The degree of pollution is a function of engine operation as measured by speed in miles per hour (MPH). Generally, as vehicle speed (MPH) increases, engine pollution decreases. Consequently, the larger the percentage increase in speed, the greater the reduction in pollutants. Thus a 5 MPH increase from 30 MPH to 35 MPH produces a larger absolute emission reduction than a 5 MPH increase from 50 MPH to 55 MPH.

Projects Which Change Speed, Delay, Usage:

- Speed - Generally (though not exclusively), projects which increase the operating speeds of a given roadway do so by increasing its capacity. Increased capacity - the ability of a roadway to accommodate more vehicles at one time - results from widening the existing roadway. Thus projects which involve widening a roadway are analyzed.

- Delay - Because there is no clean phase of engine operation, engine idling, termed vehicle delay or simply delay, is a significant contributing factor to mobile source pollution. Typically, signalization projects have a direct bearing on the amount of delay at a given location. For that reason, signalization projects are analyzed.

- Usage - Because once in operation a vehicle engine is constantly producing pollution, any project which influences the amount of vehicle usage has a direct impact on air quality. Therefore, projects such as park and ride lots and new transit service which influence use are analyzed.

Major Action Projects

The second category of projects included in this analysis are those which, due to project nature and/or scope, require, by law, that an Environmental Impact Statement (EIS), Environmental Impact Review (EIR) or Finding of No Significant Impact (FONSI) be conducted. These studies document a given project's impact on various systems and elements, one of which is air quality.

This conformancy analysis takes note of all major action projects listed on the Transportation Improvement Program. Following completion of these projects' respective reports, NMCOG will examine the appropriate air quality data and include it in this analysis. Each project which fulfills any of the above definitions is labeled as having Air Quality Significance in its TIP project description.

Projects Which Do Not Require Air Quality Analysis

The EPA and DOT have developed a list of "neutral" projects whose individual and cumulative effects would not be detected during the regional emissions analysis for plans and programs. Therefore, DOT and EPA agree these projects may be excluded from the analytical process for determining conformity of transportation plans and programs.

Furthermore, these projects normally do not require project level modeling for localized CO impacts. The DOT and EPA have agreed that emissions analysis for local CO violations should be presumed to be unnecessary for the projects listed below except for intersection channelization, intersection signalization projects, and changes in horizontal and vertical alignments. Projects in these categories should receive individual consideration to determine whether numerical project level analysis is appropriate. Projects eligible for this treatment include:

Safety

- Railroad/highway crossing
- Pavement marking demonstration
- Hazard elimination program
- Safer off-system roads
- Emergency relief (23 USC 125)
- Also specific projects for:
    - Intersection channelization projects
    - Shoulder improvements
    - Truck size and weight inspection stations
    - Safety improvement programs
    - Intersection signalization projects
    - Railroad/highway crossing warning devices
    - Changes in vertical and horizontal alignments
    - Increasing sight distance
    - Guardrails, median barriers, crash cushions
    - Pavement resurfacing and/or rehabilitation
    - Widening narrow pavements or reconstructing bridges (less than one travel lane)
    - Noise attenuation
    - Fencing
    - Skid treatments
    - Safety roadside rest areas
    - Other traffic control devices
    - Truck climbing lanes
    - Lighting improvements
    - Adding medians

Mass Transit

Purchase of office, shop, and operating equipment for existing facilities
Purchase of operating equipment for vehicles (e.g. radios, fareboxes, lifts, etc.)
Construction or renovation of power, signal and communications systems
Operating assistance
Rehabilitation of transit vehicles
Reconstruction or renovation of transit buildings and structures (e.g., rail or bus operations buildings, storage and maintenance facilities, stations, terminals, and ancillary structures)
Construction of small passenger shelters and information kiosks
Rehabilitation or reconstruction of track structures, track, and trackbed in existing rights-of-way
Noise attenuation
Purchase of support vehicles (e.g. autos, vans)
Purchase of new buses and rail cars to replace existing vehicles or for minor expansions of the fleet to provide new service
Construction of new bus and rail storage and maintenance facilities which meet the conditions for a categorical exclusion specified in 23 CFR 771

Air Quality

Continuation of ridesharing and van-pooling promotion activities at current levels
Bicycle projects
Pedestrian facilities

Other

Acquisition of scenic easements
Plantings, landscaping, etc.
Sign removal

Methodology

Each project analysis utilizes the methodology developed by the DEP and MHD. Within each analysis the following factors were employed:

- ADT - Existing ADT is factored from base year data to the appropriate study year by the current statewide average of 2.5% annually

- Emission factors - all factors are from EPA Mobile 4.1

- All emission totals expressed in kilograms. Note 453.7 grams = 1 pound while 1,000 grams = 1 kilogram.

The results of the analysis described above are illustrated in Table 1.

Air Quality Findings

As outlined in the following table, an emissions analysis has been conducted for non methane hydrocarbons (NMHC) and carbon monoxide (CO) under the build and no build scenarios. The analysis was undertaken for FY 1993-1995 projects provided that the project has sufficiently progressed in the design process to be able to obtain adequate information regarding proposed geometrics, layout, signal phasing and timing, et cetera. The results for each project are summarized in Table 1. The intersection analysis sheets for each project are provided in Appendix B.

TABLE 1
Air Quality Analysis Findings

Project Location	Analysis Year	Emissions (Kg/day) NMHC	CO
VFW Highway/Bridge St., Lowell	Build Year		
	Build	5.27	1111.55
	No Build	4.33	913.58
	Net	-0.94	-197.96
	1995		
	Build	Not	989.38
	No Build	Required	886.19
	Net		-103.18
	1996		
	Build	5.15	Not
	No Build	3.68	Required
	Net	-1.47	
	1999		
	Build	6.62	Not
	No Build	6.26	Required
	Net	0.36	

Existing Conditions Delay (Hrs./Day)	
Build	52.39
No Build	376.57
Net	-324.18

Project Location	Analysis Year	Emissions (Kg/day) NMHC	CO
Route 38/Rogers St., Improvement Project, Lowell	Build Year		
	Build	0.39	81.9
	No Build	1.34	281.7
	Net	-0.95	-199.8
	1995		
	Build	Not	82.83
	No Build	Required	245.47
	Net		-162.64
	1996		
	Build	0.45	Not
	No Build	1.29	Required
	Net	-0.84	
	1999		
	Build	0.56	Not
	No Build	1.29	Required
	Net	-0.73	

Existing Conditions Delay (Hrs./Day)	
Build	211.15
No Build	726.26
Net	-515.11

Project Location	Analysis Year	Emissions (Kg/day) NMHC	CO
Merrimack Street, Dutton Street and Arcand Drive/ Arcand Drive and French Street (Monument Square)	Build Year		
	Build	6.09	113.48
	No Build	27.00	502.63
	Net	-20.91	-389.15
	1995		
	Build	N/A	100.44
	No Build	N/A	563.68
	Net	N/A	-463.24
	1996		
	Build	6.6	Not
	No Build	39.58	Required
	Net	-0.84	
	1999		
	Build	8.23	Not
	No Build	57.06	Required
	Net	-48.83	

Existing Conditions Delay (Hrs./Day)	
Build	258.37
No Build	1144.95
Net	-886.58

In accordance with the Phase I Interim Guidance the following FY '93 projects are exempt from air quality analysis as the projects do not impact vehicle speed, usage, congestion or delay:

1. School Street Bridge, Lowell (L-15-10)
2. Wilder Street Bridge, Lowell
3. Prescott Street Bridge, Pepperell
4. River Street Bridge, Westford
5. Princeton Street Bridge (Route 3A), Chelmsford
6. Pollard Street Bridge, Billerica
7. Phineas Street Bridge, Dracut
8. Boylston Street Bridge, Lowell
9. Lundberg Street Bridge, Lowell
10. Plain Street Bridge, Lowell
11. Brown Street Bridge, Billerica
12. Gray Street Bridge, Billerica
13. Aiken Street Bridge, Lowell
14. School Street Bridge, Lowell (L-15-22)
15. Town Farm Lane, Billerica
16. Aiken Street and V.F.W. Highway, Lowell

Insufficient information exists regarding the following projects to allow an air quality analysis to be performed. All of these projects are either in the conceptual stage or in the early preliminary design phase:

1. Route 3 widening project: Completion of a revised Draft Environmental Assessment is still currently underway. The air quality analysis for the original Draft EA conducted in 1984 is included in Appendix C, however, the analysis is being redone as it is based on outdated traffic volume data. Design has not yet been initiated.

2. Route 3A/Tower Farm Road, Billerica, signalization project: The project is in the early design stage.

3. Route 3A/Pollard Street/Floyd Street, Billerica: In early design stage, insufficient information is available to allow meaningful air quality analysis.

DESCRIPTION OF FUNDING CATEGORIES

The explanations which follow outline the basic uses and requirements of each funding category as described on the Intermodal Surface Transportation Efficiency Act of 1991 and utilized in this TIP. Specific information related to a particular roadway's eligibility for these funds can be provided by NMCOG (454-8021) or the MHD District 4 office (648-6100). Questions regarding FTA funding are best directed to the LRTA (459-0164).

Highway Funding

o Interstate Maintenance - Finances such projects as reconstruction of bridges, interchanges and overpasses along existing interstate routes. The Interstate Maintenance Program does not fund the addition of new travel lanes except for high occupancy vehicle lanes and auxiliary lanes (such as truck climbing lanes). Preventive maintenance is an eligible activity when a state can demonstrate through its pavement management program that such activities are cost effective in extending pavement or bridge life.

Funding: Federal 90%/State 10%

o National Highway Program - Finances construction projects on major roadways which have been designated highways of National Significance under the 1991 Surface Transportation Assistance Act. The purpose of NHS funds is to provide an interconnected system of principal arterial routes to serve major population centers, airports and public transportation facilities, to meet national defense requirements and to serve interstate and interregional travel.

Funding: Federal 80%/State 20%

o Hazard Elimination - Finances construction and safety improvements at locations deemed hazardous in nature.

Funding: Federal 80%/State 20%

o Highway Bridge Replacement and Rehabilitation - Finances the replacement or maintenance of deficient bridges without concern for a given bridge's urban or rural setting. Uniquely, these funds may be expended on any highway bridge situated on a public road whether on or off the Federal Aid System. Projects such as replacement of the School Street Bridge in Lowell and the Prescott Bridge in Pepperell qualify for this category.

Funding: Federal 80%/State 20%

o Surface Transportation Program - Funds obligated under this category may be expended for construction, reconstruction, rehabilitation, resurfacing, restoration and operational and safety improvements for federal aid eligible roadways and bridges. STP funds may also be used for capital costs for transit projects eligible for assistance under the Federal Transit Act.

Funding: Federal 80%/State 20%

o Congestion Mitigation/Air Quality Improvement Program - Program and projects funded under this category must contribute to the attainment of a National Ambient Air Quality Standard or must be included in the State Implementation Plan pursuant to the Clean Air Act of 1990.

Funding: Federal 80%/State 20%

Transit Funding

o Section 3 (FTA) - Federal discretionary program financing capital expenditures awarded and administered by FTA.

Funding: Federal 80%/State 10%/Local 10%

NOTE: Local (State and Local) overmatch is common in this program.

o Section 9 (FTA) - Finances capital, planning and operating expenses for LRTA urban service areas. Section 9 funds are awarded and administered by FTA.

Funding for capital expenses: Federal 80%/State 10%/LRTA 10%

Funding for planning expenses: Federal 80%/NMCOG 20%

Funding for operations expenses: Federal 50%/State 25%/ LRTA 25%

o Section 18 (FTA) - Finances capital and operating expenses for transit operations in rural areas. In Massachusetts, this section is administered by the Executive Office of Transportation and Construction (EOTC).

Funding for operating expenses: Federal 50%/State 25%/LRTA 25%

Funding for capital expenses: Federal 80%/State 10%/LRTA 10%

o Section 16(b)(2) (FTA)/Mobility Assistance (State) - Finances capital expenses for private non-profit organizations to provide specialized transit services for the elderly and handicapped populations. The Massachusetts Mobility Assistance Program extends these provisions to public non-profit agencies. These awards are approved on a project by project basis, funding only capital expenses for the acquisition of specific types of vans and base station equipment. These funds do not fund operating expenses.

Funding: Federal 80%/Local 20%

Flexible Funding:

In many cases funds allocated under the categories of Surface Transportation Program, National Highway Program, and Congestion Mitigation/Air Quality may be utilized for transit projects. All funds in these categories are funded at 80% Federal/20 % State share.

Project Funding Totals (Highway)

Table 2 shows the total project costs by funding category by fiscal year. The total cost of the FY '93-"95 TIP for all federal aid funding categories is $61,526,500.

TABLE 2

Funding Totals by Funding Category by Fiscal Year

Federal Aid Projects:	FY '93	FY '94	FY '95
National Highway System	-0-	-0-	$32,400,000.
Surface Transportation Program	-0-	$300,000.	-0-
Highway Bridge Replacement and Rehabilitation	$8,563,000.	$6,975,800.	$10,000,000.
Congestion Mitigation/ Air Quality	$ 700,000.	$2,418,000.	-0-
Hazard Elimination	$ 200,000.	-0-	-0-
Total Federal Aid	$9,463,000.	$9,663,500.	$42,400,000.
Non-Federal Aid	$ 4,007,000.	-0-	-0-

LEXICON

The terms defined below are used throughout the Transportation Improvement Program (TIP).

Activity	Proposal, planning, engineering (PE), right of way (ROW), construction (CON) or reconstruction (RECON) appropriate for a given project's status.
Air Quality Significance (AQS)	Indicates a project which influences vehicle speed, delay or usage.
Implementing Agency	Identifies agency or agencies responsible for a project's planning, design and construction.
Source of Funds	Level of government(s) - Federal, State, Local - financing a project's implementation.
"T"	"T" notes a project contained in the current Comprehensive Transportation Plan.
TSM	Notes a project which employs Transportation System Management (TSM) methods to solve a transportation problem.

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FEDERAL AID REGIONAL PROJECT LISTING

$$$$$ FY 1993

Federal 80%

State 20%

Local

CONGESTION MITIGATION/AIR QUALITY

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Merrimack Street, Dutton Street, and Arcand Drive Lowell	Reconstruction of the intersections of Merrimack Street, Dutton Street, and and Arcand Drive, and French Street and Arcand Drive Project I.D.#: 040405	Federal	560	MHD
		State	140	
		Local		
AQS T		Total	700	
		Activity	CON	

$$$$$ FY 1993

Federal 80%

State 20%

Local

HAZARD ELIMINATION

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
VFH Highway, and Aiken Street Lowell	Signal upgrade. Project I.D.#: 180132	Federal	160	MHD
T		State	40	
		Local		
		Total	200	
		Activity	CON	

$$$$$ **FY 1993**

Federal 80%

State 20%

Local

HIGHWAY BRIDGE REPLACEMENT AND REHABILITATION

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
School Street Bridge, Lowell	Replace School Street Bridge over railroad tracks and canal. Project I.D.#: 127751	Federal	4480	MHD
		State	1120	
L-15-10		Local	_____	
		Total	5600	
		Activity	RECON	
Prescott St. Bridge Pepperell	Reconstruction and related work for the Prescott Street Bridge over the Nissitissit River. Project I.D.#: 058370	Federal	538.4	MHD
		State	134.6	
P-6-13		Local	_____	
		Total	673	
		Activity	RECON	
Phineas Street Bridge Dracut	Complete replacement of existing bridge and related approach roadway. Project I.D.#: 021110	Federal	960	MHD
		State	240	
D-11-5		Local	_____	
T		Total	1200	
		Activity	CON	
Plain Street Bridge Lowell	Bridge reconstruction over the Conrail Railroad. Project I.D.#: 056550	Federal	800	MHD
		State	200	
L-15-2		Local	_____	
T		Total	1000	
		Activity	RECON	

$$$$$ **FY 1993**

Federal 80%

State 20%

Local

HIGHWAY BRIDGE REPLACEMENT AND REHABILITATION

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Princeton Street Bridge (Route 3A) Chelmsford	Deck replacement over B&M Railroad and Stony Brook. Project I.D.#: 109800	Federal	72	MHD
		State	18	
C-8-3		Local		
		Total	90	
		Activity	RECON	

$$$$$ FY 1994

Federal 80%

State 20%

Local

SURFACE TRANSPORTATION PROGRAM

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Boston Road at Tower Farm Road Billerica	Geometric improvements, signals and related improvements. Project I.D.#: 006822	Federal	270	MHD
		State	30	
AQS		Local		
		Total	300	
		Activity	RECON	

$$$$$ FY 1994

Federal 80%

State 20%

Local

CONGESTION MITIGATION/AIR QUALITY

Facility - Community		Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Boston Road (Route 3A), Pollard and Floyd Street, Billerica		Reconstruction, geometric improvements and signal upgrade. Project I.D.#: 006821	Federal	654.4	MHD
			State	163.6	
			Local	_____	
AQS	T		Total	818	
			Activity	CON	
Route 38/Rogers Street Lowell		Widening and related improvements and from Clark Road to Douglas Road. Project I.D.#: 112180	Federal	1280	MHD
			State	320	
AQS	T		Local	_____	
			Total	1600	
			Activity	CON	

$$$$$ **FY 1994**

Federal 80%

State 20%

Local

HIGHWAY BRIDGE REPLACEMENT AND REHABILITATION

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Boylston Street Bridge Lowell	Bridge reconstruction over the B&M Railroad. Project I.D.#: 007105	Federal	800	MHD
		State	200	
L-15-5		Local	_____	
		Total	1000	
		Activity	RECON	
Pollard Street Bridge Billerica	Bridge reconstruction over the Concord River. Project I.D.#: 058020	Federal	1400	MHD
		State	360	
B-12-5		Local	_____	
		Total	1800	
		Activity	RECON	
Lundberg Street Bridge Lowell	Bridge reconstruction over the B&M Railroad. Project I.D.#: 040891	Federal	1500	MHD
		State	375	
L-15-6		Local	_____	
		Total	1875	
		Activity	RECON	

$$$$$ **FY 1994**

Federal 80%

State 20%

Local

HIGHWAY BRIDGE REPLACEMENT AND REHABILITATION

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Wilder Street Bridge Lowell	Bridge reconstruction and related work over B&M Railroad. Project I.D.#: 142810	Federal	1200	MHD
		State	300	
L-15-12		Local		
		Total	1500	
		Activity	RECON	
River Street Bridge Westford	Bridge reconstruction over B&M Railroad. Project I.D.#: 060950	Federal	640	MHD
		State	160	
W-26-10		Local		
		Total	800	
		Activity	RECON	

$$$$$ FY 1995

Federal 80%

State 20%

Local

NATIONAL HIGHWAY PROGRAM

Facility - Community		Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Route 3 Billerica, Chelmsford		Route 3 widening project from Route 128 to Route 129 (Phase IA) Project I.D.#: 107700	Federal	12400	MHD
			State	3100	
AQS	T		Local	_____	
			Total	15500	
			Activity	CON	
Route 3 Chelmsford, Lowell		Route 3 widening project from Route 129 to Drum Hill (Phase IIA) Project I.D.#: 107700	Federal	13520	MHD
			State	3380	
AQS	T		Local	_____	
			Total	16900	
			Activity	CON	

$$$$$ FY 1995

Federal 80%

State 20% TO BE ANNOUNCED

Local

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Bruce N. Freeman Memorial Bike Path (previously known as Lowell-Sudbury Bike Path)	Design and construction of Phase I of the Bike Path extending from Lowell to Westford. Project I.D.#: N/A	Federal	N/A	MHD
		State	N/A	
		Local	_____	
		Total	N/A	
AQS		Activity	DES/CON	

STATEWIDE FEDERAL AID

PROJECT LISTING

$$$$$ **FY 1995**

Federal 80%

State 20%

Local

HIGHWAY BRIDGE REPLACEMENT AND REHABILITATION

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Town Farm Lane Bridge Billerica	Bridge reconstruction over the B&M Railroad. Project I.D.#: 134205	Federal	800	MHD
		State	200	
B-12-11		Local	_____	
		Total	1000	
		Activity	RECON	
Brown Street Bridge Billerica	Bridge reconstruction over the B&M Railroad. Project I.D.#: 009549	Federal	800	MHD
		State	200	
B-12-14		Local	_____	
		Total	1000	
		Activity	RECON	
Gray Street Bridge Billerica	Bridge reconstruction over the B&M Railroad. Project I.D.#: 029449	Federal	800	MHD
		State	200	
B-12-14		Local	_____	
		Total	1000	
		Activity	RECON	
Aiken Street Bridge Lowell	Bridge reconstruction over the Merrimack River. Project I.D.#: 000910	Federal	4000	MHD
		State	1000	
L-15-20		Local	_____	
		Total	5000	
		Activity	RECON	

$$$$$ **FY 1995**

Federal 80%

State 20%

Local

HIGHWAY BRIDGE REPLACEMENT AND REHABILITATION

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
School Street Bridge Lowell	Bridge reconstruction over the Northern Canal Project I.D.#: 127750	Federal	1600	MHD
		State	400	
L-15-22		Local	_____	
		Total	2000	
		Activity	RECON	

$$$$$ **FY 1993**

Federal 90%

State 10%

Local

INTERSTATE MAINTENANCE

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Statewide	Infrastructure improvements; includes guardrail, call boxes, highway lighting, impact attenduators.	Federal	1080	MHD
		State	120	
		Local	_____	
		Total	1200	
		Activity	Maintenance	
Statewide	Bridge decks and bridge painting.	Federal	1200	MHD
		State	300	
		Local	_____	
		Total	1500	
		Activity	Maintenance	
Statewide	Preliminary engineering	Federal	72	MHD
		State	8	
		Local	_____	
		Total	80	
		Activity	Preliminary Engineering	

$$$$$ **FY 1993**

Federal 80%

State 20%

Local

SURFACE TRANSPORTATION PROGRAM

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Statewide	Resurfacing	Federal	960	MHD
		State	240	
		Local	_____	
		Total	1200	
		Activity	Maintenance	
Statewide	Infrastructure improvements including guardrail, call boxes, highway lighting, impact attenuators, landscaping, pavement markings, signing.	Federal	400	MHD
		State	100	
		Local	_____	
		Total	500	
		Activity	Maintenance	
Statewide	Preliminary engineering	Federal	160	MHD
		State	40	
		Local	_____	
		Total	200	
		Activity	Preliminary Engineering	

$$$$$ **FY 1993**

Federal 80%

State 20%

Local

CONGESTION MANAGEMENT/AIR QUALITY

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Statewide	Installation of State Police cellular phone lines.	Federal	80	MHD
		State	20	
		Local		
		Total	100	
		Activity	CON	
Statewide	Right of way	Federal	400	MHD
		State	100	
		Local		
		Total	500	
		Activity	CON	
Statewide	Preliminary engineering	Federal	80	MHD
		State	20	
		Local		
		Total	100	
		Activity	Preliminary Engineering	
Statewide	Electric vehicle pilot program.	Federal	2128	MHD
		State	532	
		Local		
		Total	2660	
		Activity	Demonstration Program	

$$$$$ FY 1993

Federal 80%

State 20%

Local

BRIDGES

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Statewide	Off-system footprint bridge program.	Federal	600	MHD
		State	150	
		Local	_____	
		Total	750	
		Activity	Maintenance	
Statewide	Preliminary engineering	Federal	1600	MHD
		State	400	
		Local	_____	
		Total	2000	
		Activity	Preliminary Engineering	
Statewide	Bridge inspection program	Federal	800	MHD
		State	200	
		Local	_____	
		Total	1000	
		Activity	Maintenance	
Statewide	Right of way	Federal	96	MHD
		State	24	
		Local	_____	
		Total	120	
		Activity	CON	

$$$$$ FY 1993

Federal 80%

State 20%

Local

NATIONAL HIGHWAY SYSTEM

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Statewide	Resurfacing	Federal	1600	MHD
		State	400	
		Local	_____	
		Total	2000	
		Activity	Resurfacing	
Statewide	Bridge decks and bridge repainting	Federal	1200	MHD
		State	300	
		Local	_____	
		Total	1500	
		Activity	Maintenance	
Statewide	Infrastructure improvements; includes guardrail, call boxes, highway lighting, impact attenuators, landscaping, pavement markings, signing.	Federal	1200	MHD
		State	300	
		Local	_____	
		Total	1500	
		Activity	Maintenance	

FUTURE PROJECTS

$$$$$

Future Projects

FY 1996 & 1997

Federal 80%

State 20%

Local

SURFACE TRANSPORTATION PROGRAM

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Route 129 Chelmsford	Reconstruction of Route 129 from Alpha Road to Industrial Avenue. Project I.D.#: 089003	Federal	1600	MHD
AQS T		State	400	
		Local	_____	
		Total	2000	
		Activity	CON	
Lakeview Avenue and Parham Road, Tyngsborough	Reconstruction and related intersection improvements. Project I.D.#: 500015	Federal	N/A	MHD
		State	N/A	
		Local	_____	
		Total	N/A	
		Activity	RECON	

$$$$$ Future Projects

Federal 80%

State 20%

Local

FY 1996 & FY 1997

NATIONAL HIGHWAY PROGRAM

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
I-495 Chelmsford	Lengthen roadside rest areas currently on I-495. Project I.D.#: 066101	Federal	240	MHD
		State	60	
		Local		
		Total	300	
		Activity	CON	
Route 3 Billerica, Chelmsford	Route 3 widening from Route 128 to Route 129 (Phase IB). Project I.D.#: 107700	Federal	10240	MHD
		State	2160	
AQS T		Local		
		Total	12400	
		Activity	CON	
Route 3 Chelmsford, Lowell	Route 3 widening from Route 129 to Drum Hill (Phase IIB). Project I.D.#: 107700	Federal	13520	MHD
		State	3380	
AQS T		Local		
		Total	16900	
		Activity	CON	
Route 3 Chelmsford, Westford, Tyngsborough	Route 3 widening from Drum Hill to the New Hampshire State line (Phase III). Project I.D.#: 107700	Federal	31040	MHD
		State	6960	
		Local		
		Total	38800	
		Activity	CON	

$$$$$

Future Projects

Federal 80%

State 20%

Local

FY 1996 & FY 1997

HIGHWAY BRIDGE REPLACEMENT AND REHABILITATION

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
I-495 Bridges Lowell L-15-83 L-15-84	Deck replacement for two I-495 bridges Project I.D.#: 068611	Federal	800	MHD
		State	200	
		Local	_____	
		Total	1000	
		Activity	RECON	
Andover Road Bridge Billerica B-12-13	Bridge reconstruction. Project I.D.#: 002001	Federal	800	MHD
		State	200	
		Local	_____	
		Total	1000	
		Activity	RECON	
Hale Street Bridge Lowell L-15-	Complete replacement of existing bridge over B&M Railroad. Project I.D.#:	Federal	800	MHD
		State	200	
		Local	_____	
		Total	1000	
		Activity	CON	
Route 111/119 Bridge Pepperell P-6-1	Bridge reconstruction over the Nashua River. Project I.D.#: 029910	Federal	640	MHD
		State	160	
		Local	_____	
		Total	800	
		Activity	RECON	

$$$$$

Future Projects

Federal 80%

State 20%

Local

FY 1996 & FY 1997

HIGHWAY BRIDGE REPLACEMENT AND REHABILITATION

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Riverneck Road Chelmsford	Deck replacement; Riverneck Road Bridge Bridge over Route 3. Project I.D.#: 061020	Federal	800	MHD
C-8-14		State	200	
		Local	_____	
		Total	1000	
		Activity	RECON	
Walker Street Bridge Lowell	Replace bridge over B&M Railroad. Project I.D.#: 180503	Federal	1200	MHD
L-15-11		State	300	
		Local	_____	
		Total	1500	
		Activity	RECON	
Moody Street Bridge Lowell	Reconstruction of Moody Street Bridge over the Western Canal. Project I.D.#: 500010	Federal	N/A	MHD
L-15-48		State	N/A	
		Local	_____	
		Total	N/A	
		Activity	RECON	

NON FEDERAL AID PROJECTS

Fac
Com

Ran
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B-1
B-1

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Low

$$$$$ FY 1993

Federal

State 100% NON FEDERAL AID

Local

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Rangeway Road/ Manning Road Billerica	Bridge reconstruction for two bridges over Route 3. Project I.D.#: 005805	Federal		
		State	475	MHD
B-12-25 B-12-26		Local	____	
		Total	475	
		Activity	RECON	
Route 3A/North Road/Princeton Street Chelmsford	Signal upgrade. Project I.D.#: 109805	Federal		
		State	200	MHD
		Local	____	
		Total	200	
		Activity	CON	
Route 113 Lowell/Dracut	Resurface Route 113 in Lowell and Dracut for a distance of 3.6 miles. Project I.D.#: 081455	Federal		
		State	600	MHD
		Local	____	
		Total	600	
		Activity	RESURF	

$$$$$ FY 1993

Federal

State 100% **NON FEDERAL AID**

Local

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
VFW Highway at Mammoth Road and University Avenue Lowell	Signal upgrade and related improvements at two locations. Project I.D.#: 180133	Federal		
		State	232	MHD
		Local	_____	
		Total	232	
		Activity	CON	
VFW Highway Lowell	Resurfacing of VFW Highway in Lowell. Project I.D.#: 180131	Federal		
		State	1200	MHD
		Local	_____	
		Total	1200	
		Activity	RESURF	
Route 3A/ Middlesex Road Tyngsborough	Signal upgrade at two locations: (1) Middlesex Road and Westford Road (2) Middlesex Road and Kendall Road Project I.D.#: 160095	Federal		
		State	300	MHD
AQS		Local	_____	
		Total	300	
		Activity	RECON	

TRANSIT PROJECTS

FY 1993 - 1995

$$$$$ FY 1993

Federal 80%

State 10%

Local 10%

SECTION 3

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Capital Assistance LRTA	Replace 13 GMC RTA buses with 35-40 foot heavy duty wheelchair lift equipped transit coaches. Purchase radios and fareboxes for these vehicles.	Federal	2340	LRTA
		State	585	
		Local	_____	
		Total	2925	
		Activity		

$$$$$ FY 1993

	Capital	Operating
Federal	80%	50%
State	10%	25%
Local	10%	25%

SECTION 9

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Operating Assistance LRTA	Improve and maintain fixed route bus service and special services to the elderly and handicapped.	Federal	1265	LRTA
		State	1291	
		Local	810	
		Total	3366	
		Activity		
Capital Assistance	Bus and bus related facilities	Federal	312	LRTA
	Spare parts	State	39	
	Four 16-18 passenger minibuses	Local	39	
	Federal match for two mobility assistance program vehicles	Total	390	
		Activity		
	Paige Street Transit Center renovations			
	ADA accessibility improvements to CAGTT			
	Computer equipment and software (Administrative and Road Runner)			
	Rehab administrative offices			
	Administrative/supervisory vehicle			
	Bus garage improvements: Bus lift rehabilitation Pumping system replacement			
Planning Assistance	Planning contract with NMCOG	Federal	48	LRTA
		State		
		Local	12	
		Total	60	
		Activity		

$$$$$ FY 1993

Federal 20%

State 80%

Local

MOBILITY ASSISTANCE PROGRAM

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Capital Assistance	Purchase eight lift equipped vehicles for E&H service - six for replacement two additional for ADA "floater" vehicles	Federal	68	LRTA
		State	274	
		Local		
	Road Runner computerized paratransit scheduling system upgrade (partial)	Total	342	
		Activity		

$$$$$ FY 1994

	Capital	Operating
Federal	80%	50%
State	10%	25%
Local	10%	25%

SECTION 9

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Operating Assistance	Fixed route	Federal	1328	LRTA
		State	1356	
		Local	830	
		Total	3514	
		Activity		
Capital Assistance	Bus and bus related facilities	Federal	113	LRTA
	Spare parts	State	184	
LRTA	Federal match for four mobility assistance program vehicles	Local		
		Total	297	
	Lift replacement for Tewksbury maintenance facility Phase II two lifts.	Activity		
Planning Assistance	Planning contract with NMCOG	Federal	49.2	LRTA
LRTA		State		
		Local	12.3	
		Total	61.5	
		Activity		

$$$$$ **FY 1994**

Federal 20%

State 80% **MOBILITY ASSISTANCE PROGRAM**

Local

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Capital Assistance	Purchase of lift equipped vehicles for E&H service	Federal	41	LRTA
		State	166	
LRTA		Local		
		Total	207	
		Activity		

$$$$$ FY 1995

	Capital	Operating
Federal	80%	50%
State	10%	25%
Local	10%	25%

SECTION 9

Facility - Community	Project Description	Source of Funds	Est. Cost (000's)	Implementing Agency
Operating Assistance	Fixed route	Federal	1395	LRTA
		State	1423	
LRTA		Local	851	
		Total	3669	
		Activity		
Capital Assistance	Bus and bus related facilities	Federal	41.6	LRTA
	Spare parts	State	10.4	
LRTA	Radio system for E&H vehicles	Local		
		Total	52	
		Activity		
		Federal	50.4	LRTA
Planning Assistance	Planning contract with NMCOG	State		
		Local	12.6	
LRTA		Total	63	
		Activity		

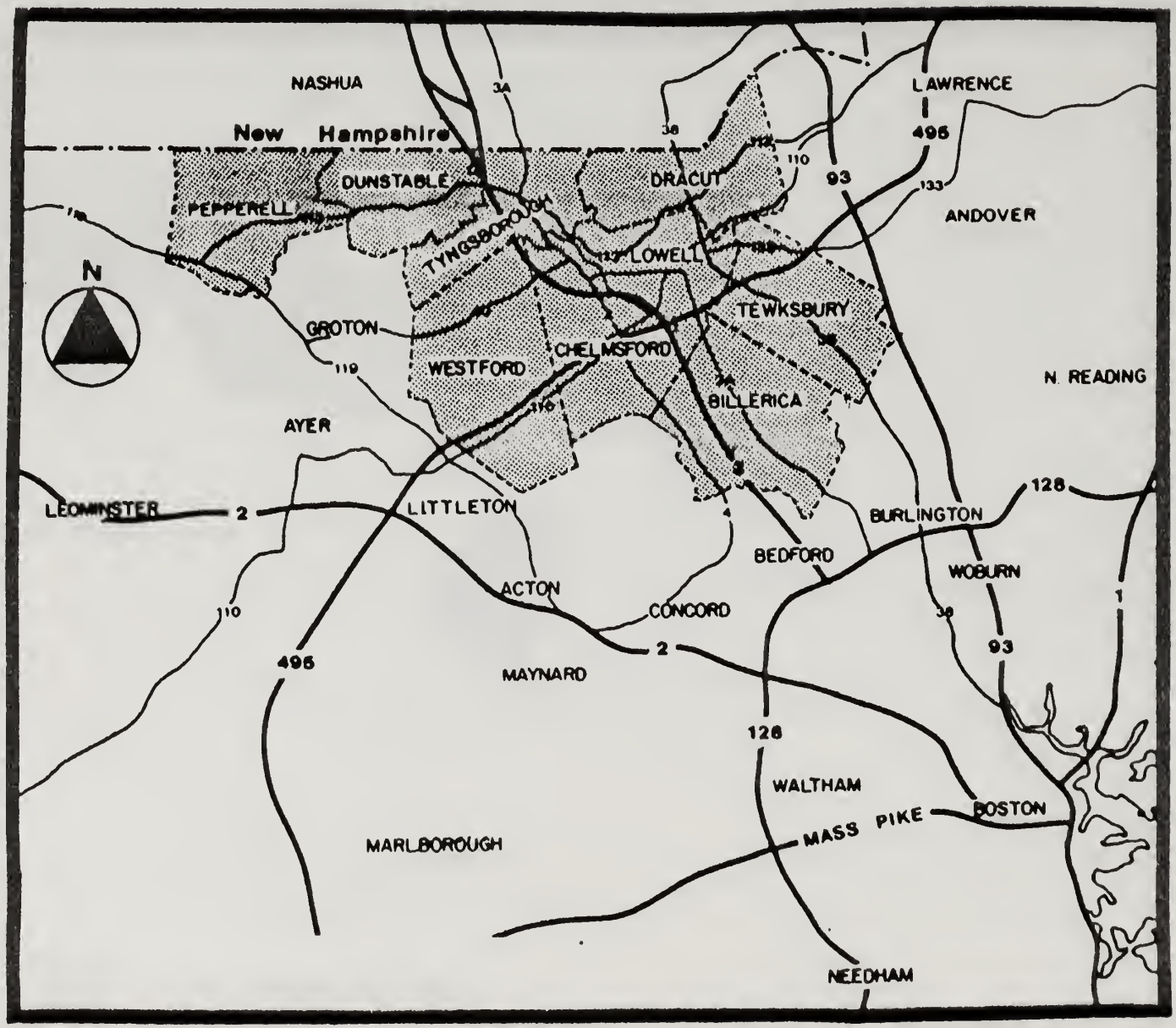
MAPS:

I. NORTHERN MIDDLESEX COUNCIL OF GOVERNMENTS' REGION

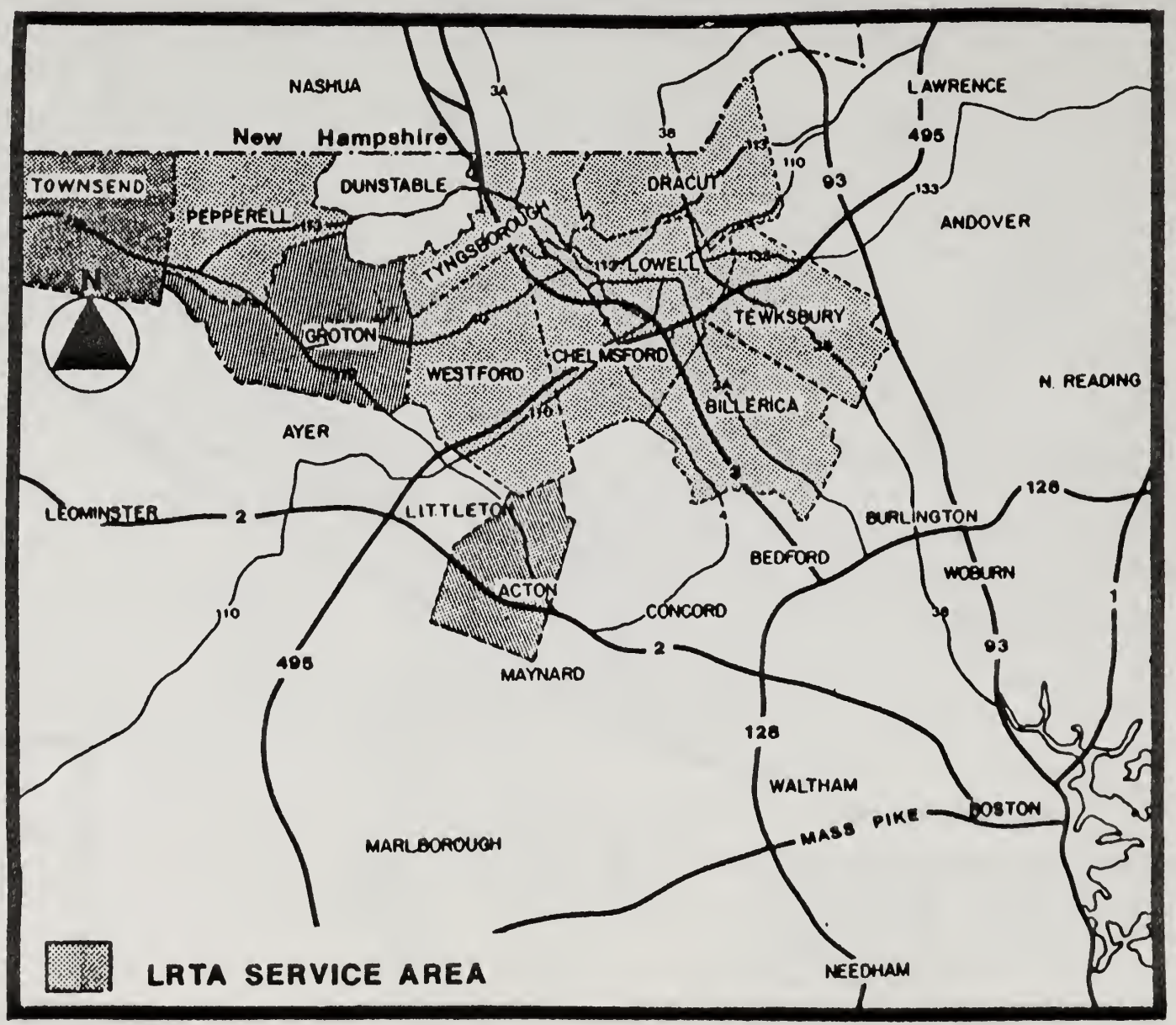
II. LRTA SERVICE AREA

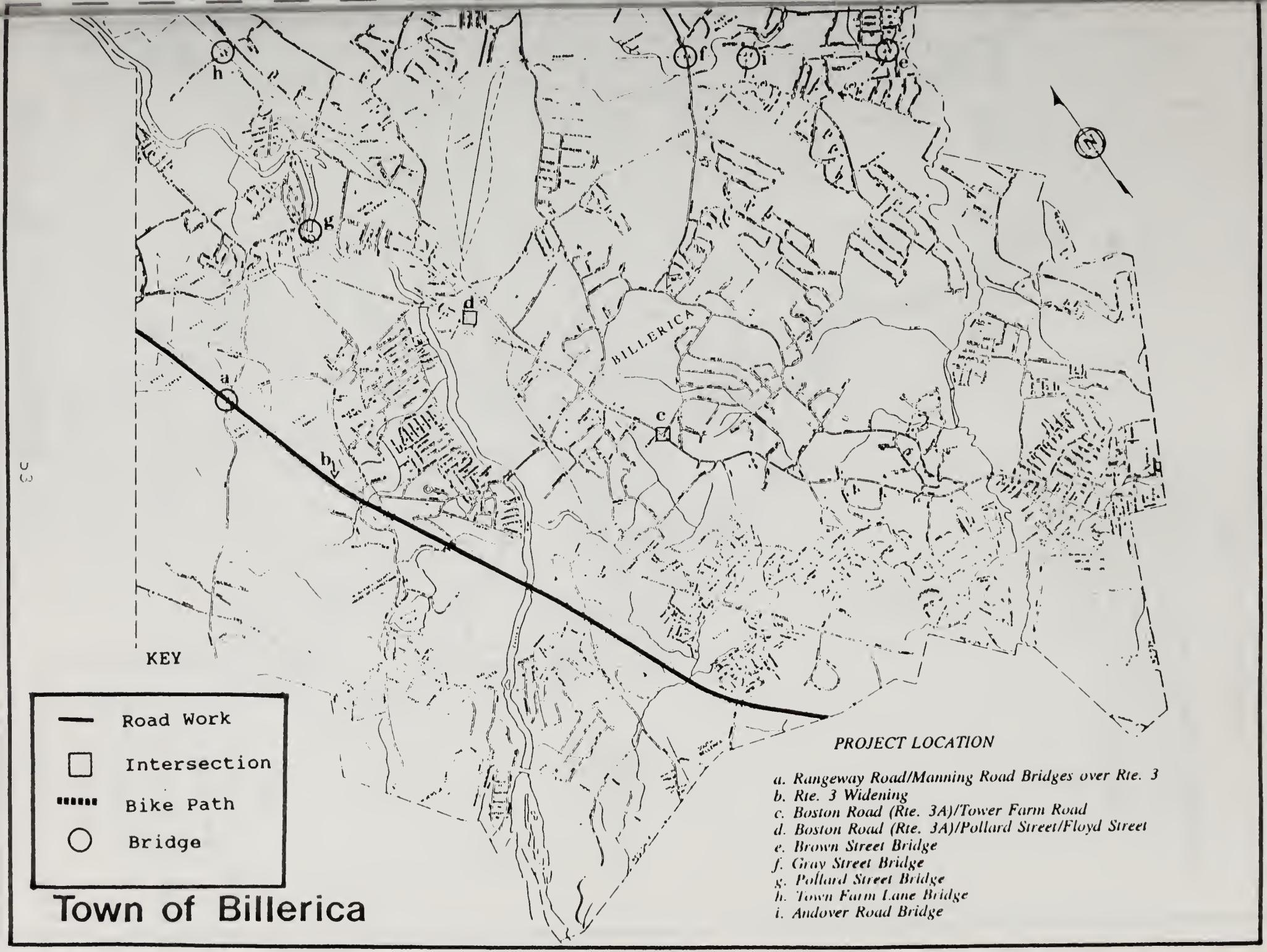
III. HIGHWAY PROJECT LOCATIONS

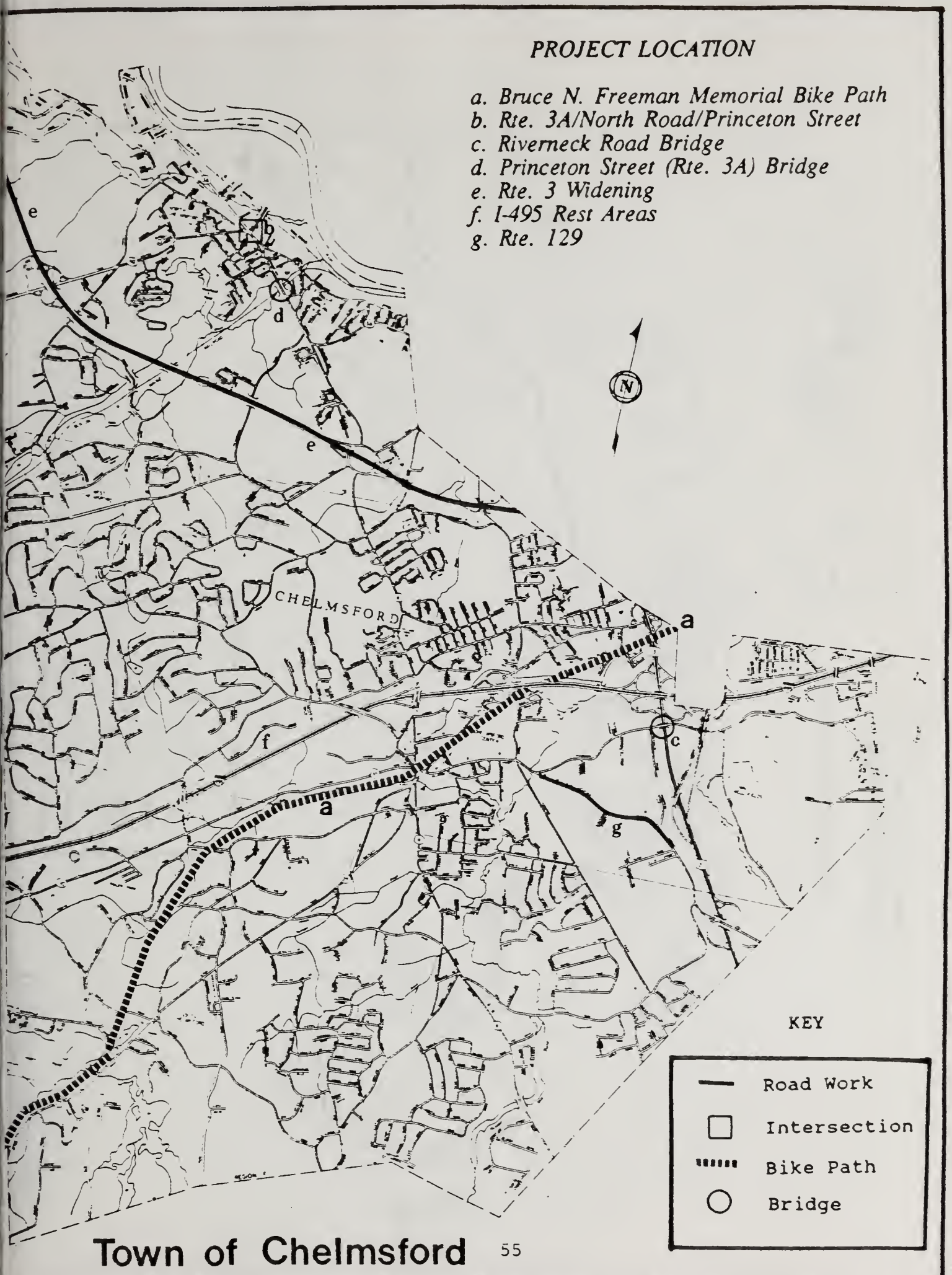
NORTHERN MIDDLESEX COUNCIL OF GOVERNMENTS REGION



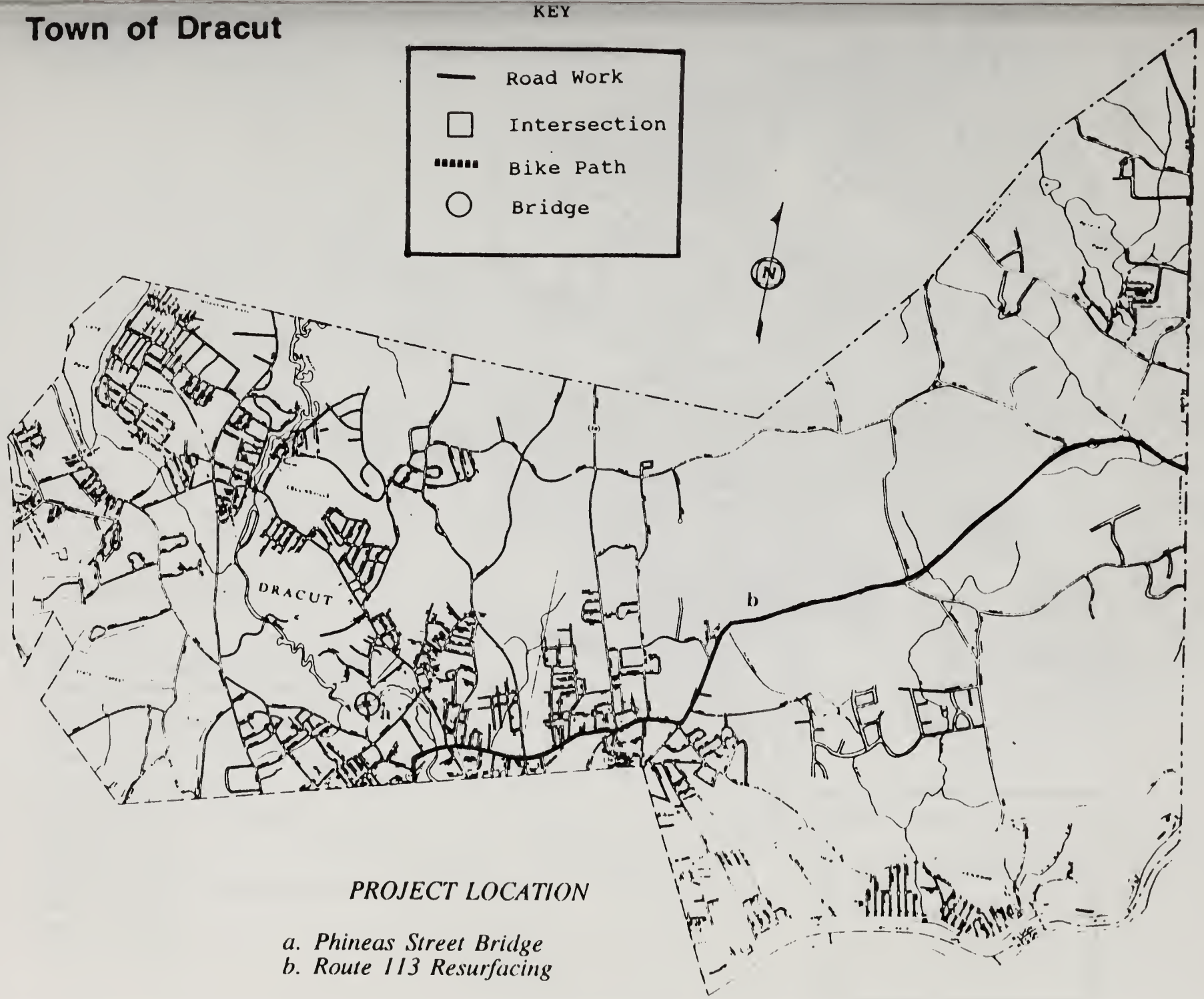
LOWELL REGIONAL TRANSIT AUTHORITY SERVICE AREA




BILLERICA
a
b
c
d
e
f
g
h
i
KEY
Road Work
Intersection
Bike Path
Bridge
Town of Billerica
PROJECT LOCATION
a. Rangeway Road/Manning Road Bridges over Rte. 3
b. Rte. 3 Widening
c. Boston Road (Rte. 3A)/Tower Farm Road
d. Boston Road (Rte. 3A)/Pollard Street/Floyd Street
e. Brown Street Bridge
f. Gray Street Bridge
g. Pollard Street Bridge
h. Town Farm Lane Bridge
i. Andover Road Bridge


PROJECT LOCATION
a. Bruce N. Freeman Memorial Bike Path
b. Rte. 3A/North Road/Princeton Street
c. Riverneck Road Bridge
d. Princeton Street (Rte. 3A) Bridge
e. Rte. 3 Widening
f. I-495 Rest Areas
g. Rte. 129
N
CHELMSFORD
a
b
c
d
e
f
g
KEY
Road Work
Intersection
Bike Path
Bridge

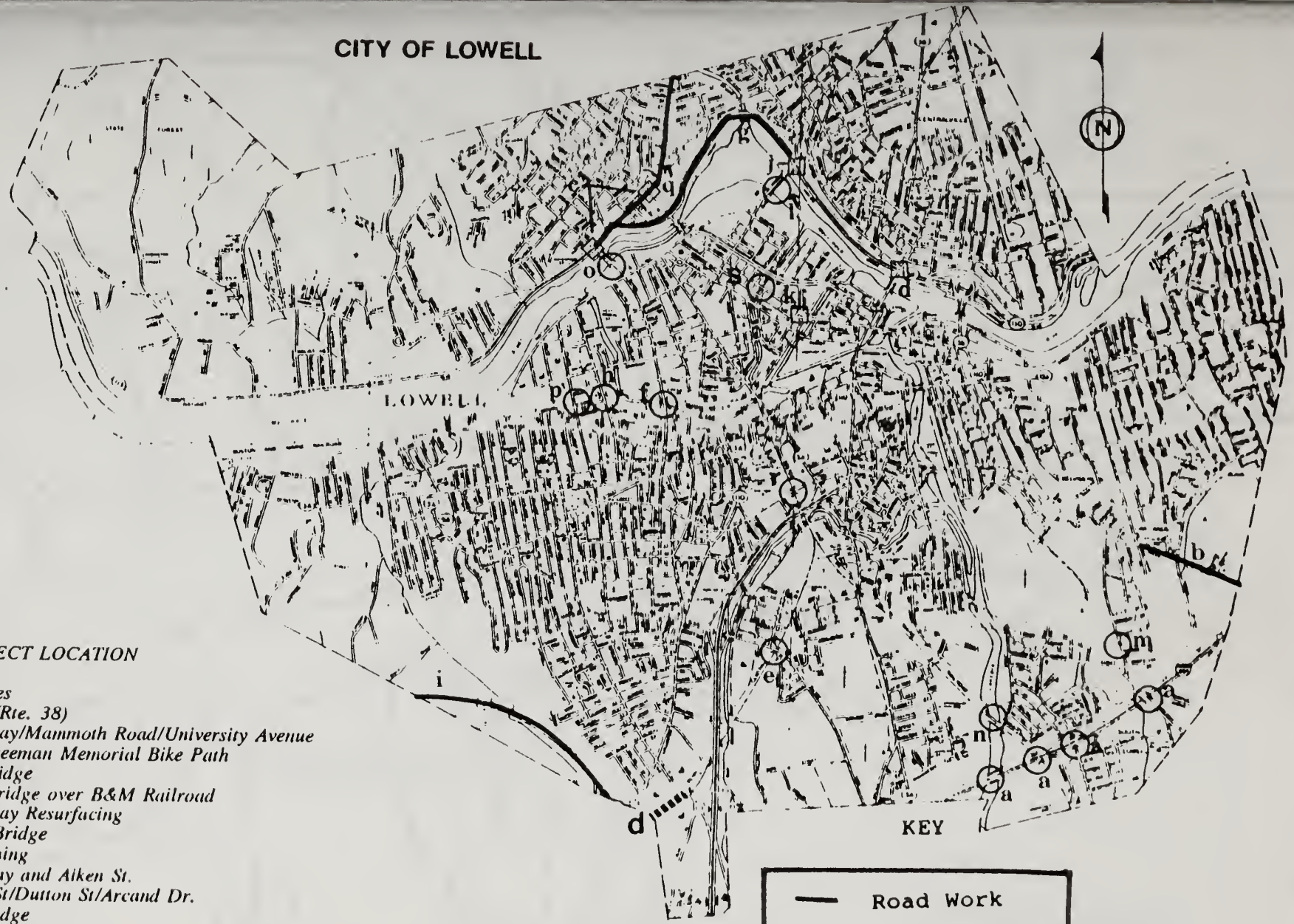
Town of Dracut



PROJECT LOCATION

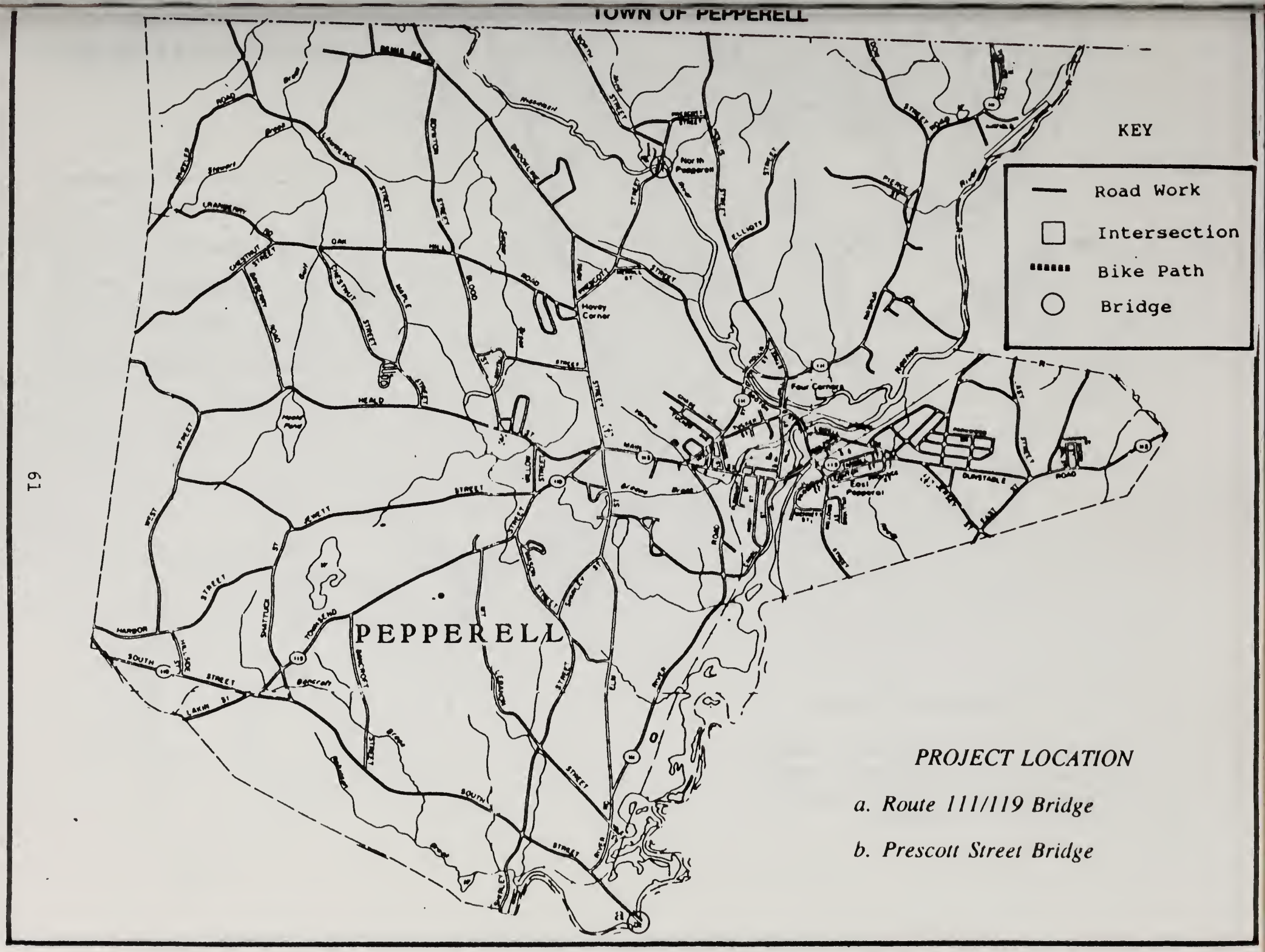
a. Phineas Street Bridge
b. Route 113 Resurfacing

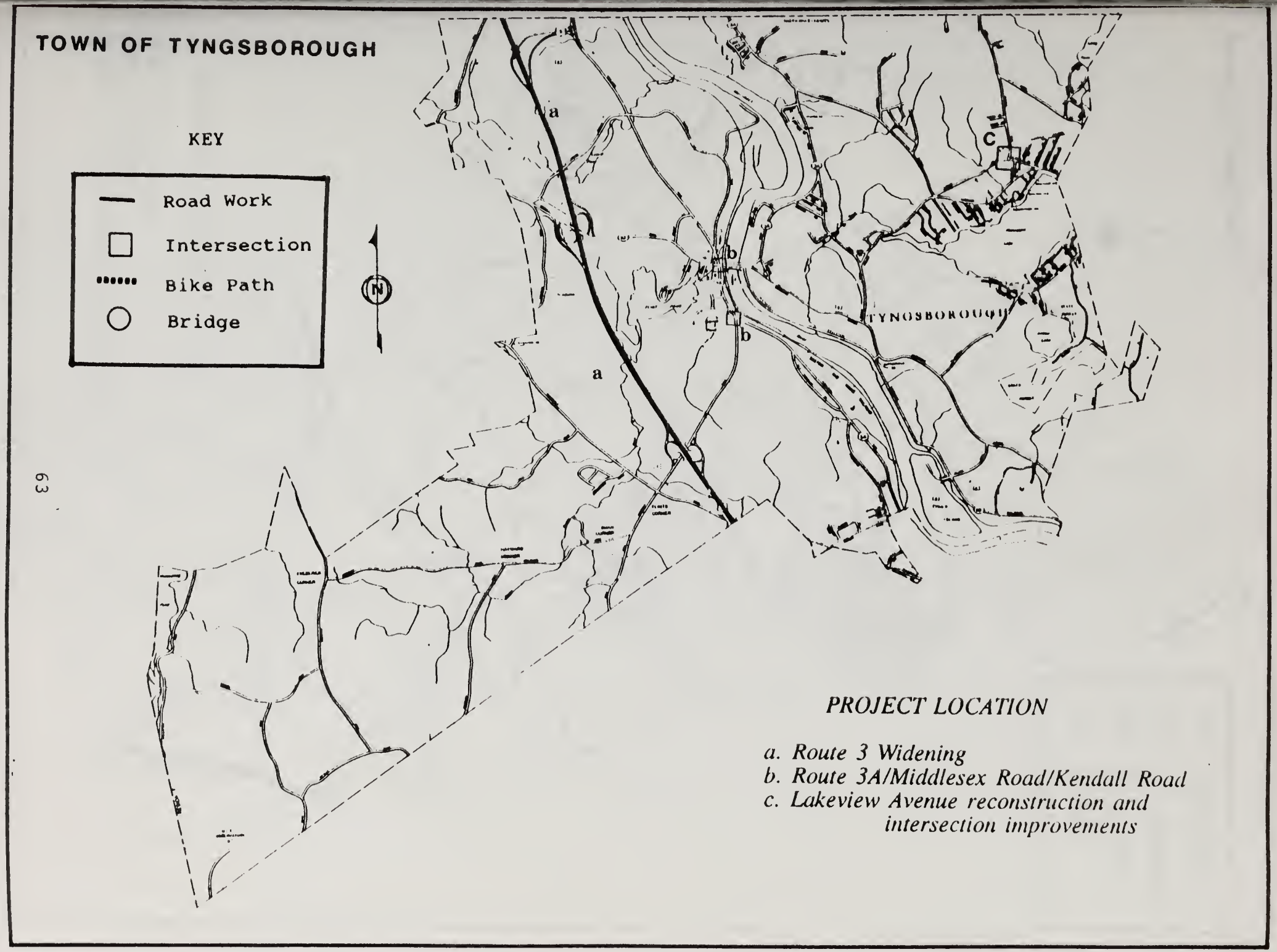
CITY OF LOWELL

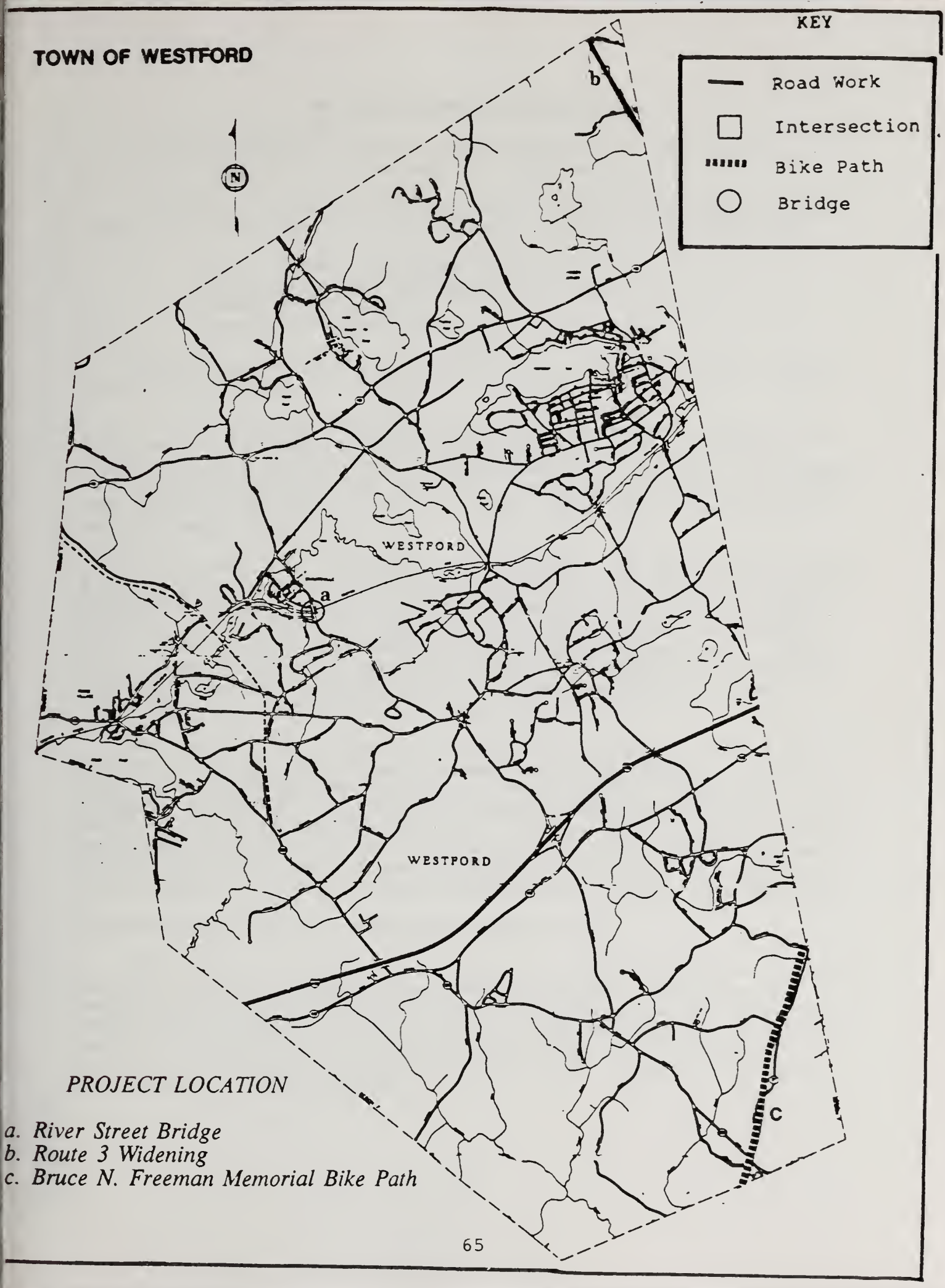


PROJECT LOCATION

a. I-495 Bridges
b. Rogers St. (Rte. 38)
c. VFW Highway/Mammoth Road/University Avenue
d. Bruce N. Freeman Memorial Bike Path
e. Plain St. Bridge
f. School St. Bridge over B&M Railroad
g. VFW Highway Resurfacing
h. Walker St. Bridge
i. Rte. 3 Widening
j. VFW Highway and Aiken St.
k. Merrimack St/Dutton St/Arcand Dr.
l. Aiken St. Bridge
m. Boylston St. Bridge
n. Lundberg St. Bridge
o. School St. Bridge over Northern Canal
p. Wilder St. Bridge
q. Route 113 Resurfacing
r. Hale Street Bridge
s. Moody Street Bridge


TOWN OF PEPPERELL
KEY
Road Work
Intersection
Bike Path
Bridge
PEPPERELL
North Pepperell
Harvey Corner
Four Corners
East Pepperell
PROJECT LOCATION
a. Route 111/119 Bridge
b. Prescott Street Bridge


TOWN OF TYNGSBOROUGH
KEY
Road Work
Intersection
Bike Path
Bridge
N
a
a
b
b
c
TYNGSBOROUGH
PROJECT LOCATION
a. Route 3 Widening
b. Route 3A/Middlesex Road/Kendall Road
c. Lakeview Avenue reconstruction and intersection improvements



PROJECT LOCATION

a. River Street Bridge
b. Route 3 Widening
c. Bruce N. Freeman Memorial Bike Path

PRIVATE SECTOR PARTICIPATION

The LRTA demonstrates a long history of involving the private sector in the provision of LRTA services.

All LRTA service is contracted to private operators through operating contracts with the following private bus operators:

LoLaw Transit Management, Inc.
Leasing Systems Development Corporation
Tewksbury Transit
Ronald H. Rajaniemi Company

These contractors participate actively in the LRTA capital planning process.

The Northern Middlesex Metropolitan Planning Organization (MPO) which includes both the LRTA Advisory Board and the Northern Middlesex Council of Governments has adopted a "Private Sector Policy" consistent with UMTA requirements as set forth in the Federal Register October 22, 1984. The policy was formally adopted March 26, 1987.

It is part of this policy to circulate the TIP and all other MPO Certification Documents to "Private Sector" transportation providers in the area. A list of these providers is included at the end of this section. Both the TIP and the UWP have been circulated to this list during the previous fiscal year. There are no new services or service proposals contained in this TIP and therefore no opportunities for increased private sector involvement or proposals to be solicited.

During FY '87, however, in accordance with the FTA policy of opening existing contracts to competition the LRTA put out to competitive bidding its entire E&H (Road Runner) operation. In addition management services for fixed route operations were competitively bid in the Fall of 1987. During this process no impediments to private sector involvement have been made apparent. No private sector complaints have been received. LRTA is currently operating on five year contracts for fixed route and E&H.

Private Sector Capital Investment Strategies

The LRTA continues to be active in the planning and development of a public/private joint venture project involving a satellite bus facility/pedestrian access on Authority owned land immediately adjacent to the Charles A. Gallagher Transportation Terminal. The public portion of this project is presently nearing completion and marketing efforts to attract a "private" development client continue.

Both public and private interests were represented on the planning committee for this project. The committee was chaired by the director of the Lowell Plan, representing the interests of private sector commercial and industrial enterprises in Lowell. Additional members represent the LRTA, the Chambers of Commerce Northern Middlesex, City of Lowell (City Manager's Office and the Division of Planning and Development) the Commonwealth of Massachusetts Division of Capital Planning and Operations (DCPO). Other resources available to the committee and attending most meetings are the Commonwealth of Massachusetts EOTC, LoLaw Transit Management (LRTA's largest private operator), NMCOG, and UMTA. The planning studies that have gone into the preparation of this project are listed on Page 2 of this TIP.

Financial Capacity:

The LRTA reviews its financial capacity annually relative to the availability of Federal funds, State funding, and local assessment. Federal funding involves the availability of FTA Section 9 apportionments, carryover funding, and funds that may be de-obligated from previous grants for capital, planning and operating assistance. State funding is available to LRTA to match Federal Capital and operating assistance. Additional State "contract assistance" funding is available from time to time primarily for assistance to capital projects. Member communities are assessed for local share based on service received. The level of assessment to member communities is limited to increase only 2.5% per year under Massachusetts' Proposition 2 1/2. Local assessments are used to match Federal capital and operating funds. The Northern Middlesex Council of Governments (NMCOG) provides local match for planning activities in which it participates.

The present LRTA Administration, which started in 1983, has instituted an improved program of monitoring capital and operating expenses through monthly status reports. Additional projections and analysis are done at the time of budget preparation. As a result, LRTA has been able to keep operating expenses within Proposition 2 1/2 and maintain tight control of the amount that needs to be borrowed in anticipation of revenues. An additional benefit to this strong financial position has been aggressive bidding by banks for this borrowing, resulting in improved interest rates.

For the Gallagher Terminal addition project, $1.34 million of federal money is leveraging $1.34 of State EOTC Capital Assistance Program money, $540,000 local share, 2.5 million MBTA Bond Issue money and $2.5 million Mass Off-Street Parking money for a total of 8.6 million for the public portion of the project which could generate additional private investment.

It is anticipated that when a public/private partnership is negotiated it will generate an estimated $250,000 in revenue annually for LRTA to the direct benefit of local transit operations. The public portion as presently constituted will save the LRTA $12,000.00 per year in rent for the Road Runner Operation and through a change in design to accommodate additional office space, LRTA will receive an additional $22,000.00 per year in rent from the Northern Middlesex Council of Governments.

Because of its revenue generation potential this project is viewed as a positive investment in the future by LRTA. Federal capital and operating revenues will be stretched tight during the next two years but not to the point of affecting service. Upon completion, however, the revenue generated by the private portion of the project will permit LRTA to maintain its present level of service in the face of potentially declining operating subsidies.

[awea-hha.abr]

Private Transportation Providers Operating in LRTA Service Area

Bus Lines

Provider	Address	Telephone
National School Bus	15 Pevey Street, Lowell	458-3316
	Ward Way, North Chelmsford	251-4901
Trombly Motor Coach	1480 Broadway Road, Dracut	453-1932
Hudson Bus Lines	16 Pond Street, Nashua	649-6061
Leasing Systems Development Corporation*	391 School Street, Lowell	475-4310
Chelmsford Council on Aging*	1 North Road, Chelmsford	256-0013
Dracut Council on Aging*	951 Mammoth Road, Dracut	957-2611
Tyngsborough Council on Aging*	Lakeview Avenue, Tyngsborough	649-9211
Rajaniemi, Inc.*	368 Main Street, Townsend	597-2687
LoLaw Transit Management, Inc.*	Clark Road, Tewksbury	452-6161
Hillcrest Wheel Chair Service	P.O. Box 165, Dracut	947-5109
Bay State Ambulance & Wheelchair Service	154 Moody Street, Lowell	458-6321
Laidlaw Transit	58 Union Street, Methuen	683-7034
Handi-Van	40 Perry Street, Lowell	453-4317
Pierce Transit	441 Textile Avenue, Dracut	957-2016
EMT Corp. (Everyday Medical Transportation, Brian Mercer, Pres.)	75 Hillside Avenue, Lawrence	686-1199
Medicar, Inc.	41 Osgood Street, Lowell	459-3848
(Contacts: Marlene Kaplin or Sotheavy Lee)		452-3382
R.C. Herrmann Bus Company	250 Littleton Road, Westford	692-3143
Trailways Bus System**	101 Thorndike St., Lowell	459-7101
Vermont Transit**	101 Thorndike St., Lowell	459-7101
Peter Pan**	101 Thorndike St., Lowell	459-7101
Lowell Transportation, Inc.	246 Adams St., Lowell	453-5981
Medical Ride	16 Pine St., Lowell	453-8717
Trinity Health Care Transport	170 Perry St., Lowell	441-9999

*Under contractual agreement with LRTA
**Sent only letter detailing policies regarding private agencies and transit. Documents will be sent upon request.

Charters/Rentals

A & F Bus Co., Inc.	16 Wyman Road, Billerica	663-8145
Bedford Charter Service**	11 Railroad Avenue, Bedford	275-9524
Shaughnessy FL, Inc.**	489 Boston Road, Billerica	667-8244
Buckingham Bus Service	Station Avenue, Groton	448-6057
Fiore Bus Service	1480 Broadway, Dracut	453-1932
Blanchard Transit Service	555 Whipple Road, Tewksbury	851-9863
Dunbar Bus Company	Tyngsborough, MA	251-7445
Far Horizons Travel Agcy.	235 Chelmsford St., Chelmsford	256-9060
Michaud Bus Lines, Inc.	3 Jean Lane, Chelmsford	441-2000
A.J. Gagnon & Sons	Gagnon Drive, Dracut	957-3100
Ryder Transportation Service	100 Littleton Road, Westford	692-0232
Trombly Commuter Lines	1480 Broadway Rd., Dracut	937-3626

**Sent only letter detailing policies regarding private agencies and transit. Documents will be sent upon request.

Taxi Service

Provider	Address	Telephone
Community Cab	117 Main Street, Pepperell	433-9944
Harlow Cab	19 West Street, Pepperell	433-8370
A&L Taxi	115 Congress, Lowell	454-5661
Diamond Yellow Cab	50 Payne Street, Lowell	458-6861
Chelmsford Town Taxi	North Chelmsford	251-8858
Fred's Taxi	42 Crimson Road, Billerica	667-2300
Billerica Taxi	1 Edgbaston Street, Billerica	663-8222
TWC Limo and Taxi	33 Nabnasset Street, Westford	692-8880
Absolute Limousine Service	Billerica, MA	1-800-338-5466
Broadway Cab Company	50 Payne St., Lowell	458-4769
Checker Taxi of Greater Lowell	33 Nabnasset Rd., Westford	251-8858
City Cab Company	50 Payne St., Lowell	454-7748
Continental Taxi	172 Lakeview Ave., Lowell	934-0888
Eagle Cab Co.	115 Congress St., Lowell	454-5421
East End Taxi	115 Congress St., Lowell	458-4655
J & N Taxi	115 Congress St., Lowell	458-8833
Moonlight Coach	4 Fletcher Lane, Westford	692-7234
Pelham Taxi	Pelham, New Hampshire	635-9313
Rio Taxi	115 Congress St., Lowell	452-5481
Textile Cab	115 Congress St., Lowell	452-6764
Tyngsborough Taxi & Airport Service	Tyngsborough, MA	649-7775
Wilmington Taxi	Wilmington, MA	658-3859

MASS. Y3. NMM1: 1/3/993/app.

Transportation Improvement Program

GOVERNMENT DOCUMENTS COLLECTION

MAY 1 1993

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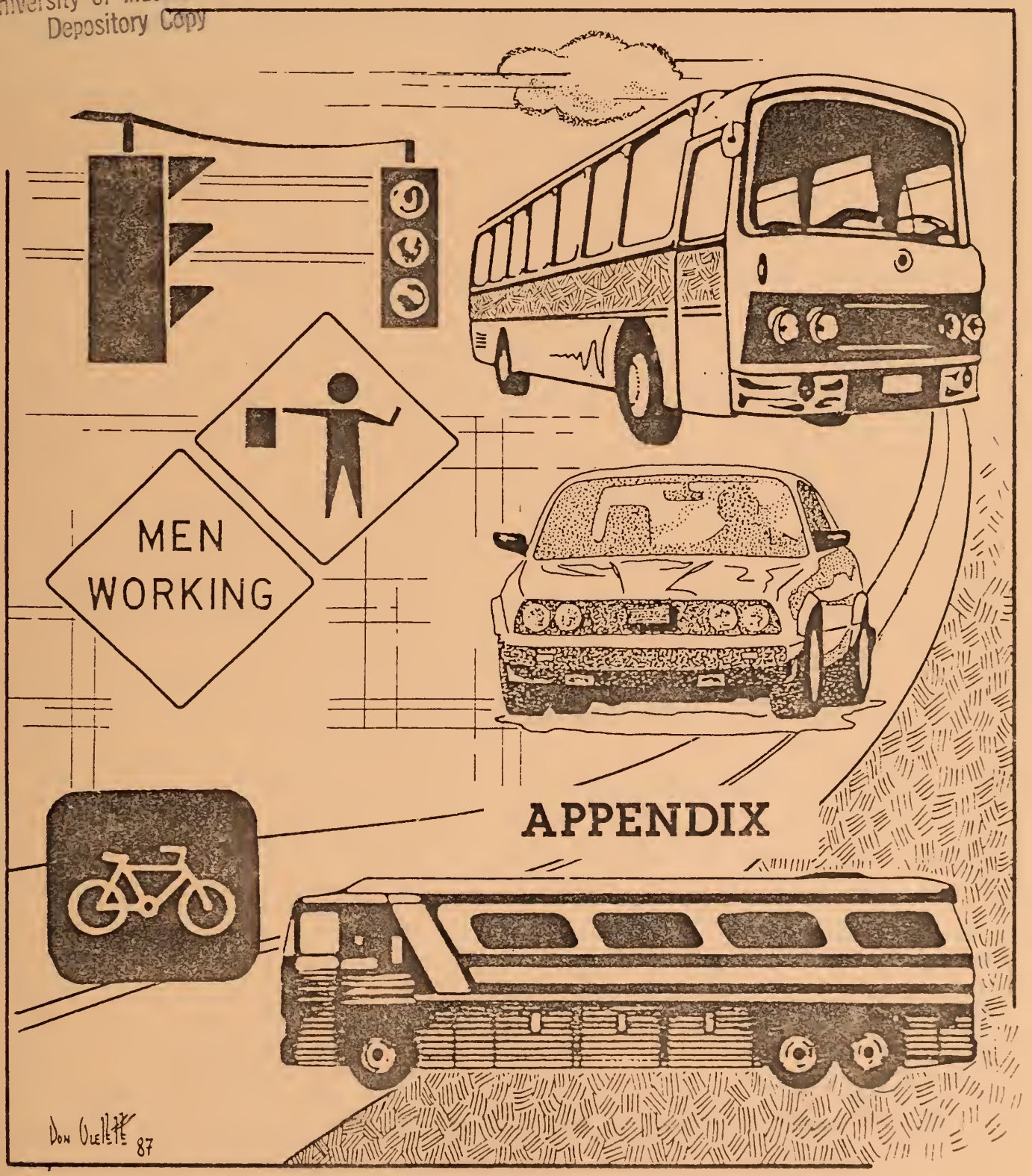
FISCAL YEAR 1993



prepared by: Northern Middlesex Metropolitan Planning Organization

APPENDIX A

TRANSPORTATION CONTROL MEASURES STATUS REPORT

Transportation Control Measures Status Report

In 1982 the Northern Middlesex Metropolitan Planning Organization committed to the implementation of the following categories of transportation control measures:

1. Park and Ride/Fringe Parking Lots
2. Employer Based Carpool/Vanpool
3. Traffic Flow Improvements

At that time it was estimated that a total target reduction in NMHC emissions of 36.91 Kg/day would be realized by 1987. While the region has implemented each of these measures, recent tracking and evaluation by the Northern Middlesex Council of Governments staff and the Massachusetts Department of Environmental Protection has found that an emission reduction of 101.3 Kg/day was actually realized. This is far in excess of the anticipated goal. (See tables following this status report for documentation.)

The region, however, remains a non-attainment area for ground level ozone and the City of Lowell is a non-attainment area for carbon monoxide. This is largely due to the phenomenal growth which occurred during the 1980s. This growth served to offset all gains made through the implementation of the above mentioned control measures.

The Northern Middlesex Metropolitan Planning Organization continues to implement additional control measures in the categories of traffic flow improvements, transit improvements, and park and ride lots.

Several traffic flow improvements are identified and analyzed in greater detail in the FY'93 Transportation Improvement Program.

Traffic flow improvement projects in the FY'93 Transportation Improvement Program include the following:

1. Route 38/Rogers Street, Lowell

2. Bridge Street/VFW Highway and Lakeview Avenue, Lowell

3. Route 3 widening project in Billerica, Chelmsford, Lowell, Westford and Tyngsborough

4. Merrimack Street, Dutton Street, and Arcand Drive

5. Boston Road, Pollard and Floyd Streets, Billerica

6. Boston Road and Tower Farm Road, Billerica

7. Crosby Drive and Middlesex Turnpike, Billerica

The NMCOG staff is presently completing a Park and Ride Lot study. The study will serve to identify suitable locations for

additional lots along the Route 3 and I-495 corridors. The Northern Middlesex Council of Governments is also encouraging the formation of a Transportation Management Organization for business along the Route 3 Corridor. Such a TMO would provide vanpool/carpool matching for area employees.

The Lowell Regional Transit Authority recently constructed additional parking facilities at the Gallagher Terminal in Lowell. It is hoped that this new facility will serve to encourage increased usage of public transportation thereby reducing VMT.

[tip-app.ar]

TABLE V - 4

(PC) ADOPTED RACMs FOR NIDC EMISSION CREDITS: 1979-1982 (CATEGORY 1A)

RACM MEASURES	Statewide DOTC	Regional Planning Commissions											
		MAPC	MVPC	NMAC	OCPC	SRPEDD	MVC	OCP EDD	NP EDD	CMRPC	LPV RPC	BCRPC	MRPC
Improved Public Transit		X					X	X	X	X	X	X	X
Exclusive Bus, Carpool Lane Area rideshare program		X					X	X	X				
Private Car Restrictions													
On-street Parking Controls		X					X		X				
Long-Range Transit Improvements													
Park & Ride Fringe Parking Lots		X		X		X	X	X	X		X		X
Pedistrian Malls ARZ													
Employer-Based Carpool/ Vanpool			X					X		X	X		X
Bicycle Lanes and Storage Facilities			X					X	X		X		
Variable Work Hours											X		X
Traffic Flow Improvements		X				X					X	X	X
Road Pricing	X	X											

SOURCE: RPC data supplied to DEQE

TABLE V - 4 (cont.)

RACM CATEGORIES ADOPTED FOR TARGET REDUCTIONS (CATEGORY 1B)

RACM Measure	Regional Planning Agencies												
	State-wide DOTC	MAPC	MVPC	NMAC	OCPC	SRPEDD	MVC	OCP TDD	NP EDD	CTRPC	LJV RPC	BCRPC	MRPC
Improve Public Transit			X			X	X	X	X	X	X		X
Exclusive Bus, Carpool Lane Area rideshare program							X	X					
Private Car Restrictions													
On-street Parking Controls					X	X							
Long Range Transit Improvements				X									
Park & Ride Fringe Parking Lots		X	X	X	X	X							
Pedestrian Malls ARZ													
Employer-Based Carpool/ Vanpool				X		X		X			X		
Bicycle Lanes and Storage Facilities		X	X				X		X		X		
Variable Work Hours			X										
Traffic Flow Improvements		X	X	X	X	X				X	X	X	X
Road-Pricing													

SOURCE: RPC data supplied to DEQE

TABLE V - 4 (cont.)

MPO RACM s- PROJECTS REQUIRING FURTHER STUDY: CONTINGENCY (CATEGORY 2)

RACM Measures	Regional Planning Commissions												
	State-Wide EOTC	MAPC	MVPC	NMAC	OCPC	SRPEDD	MVC	CCP & EDD	NP & EDD	CMRPC	LPV RPC	BCRPC	MRPC
Improved Public Transit	X	X		X	X		X		X	X		X	X
Exclusive Bus/Carpool Lane: Area rideshare	X	X	X	X	X	X			X	X			X
Private Car Restrictions		X								X			X
On-Street Parking Controls			X	X	X					X	X	X	X
Long-Range Transit Improvements		X	X		X						X	X	X
Park & Ride Fringe Lots		X	X	X	X			X		X		X	X
Pedestria Malls ARZ		X		X							X	X	X
Employer Based Carpool/Vanpool	X	X			X					X		X	X
Bicycle Lanes & Storage Facilities		X	X		X		X	X	X	X	X	X	X
Variable Work Hours		X			X					X		X	X
Traffic Flow Improvements		X	X	X	X	X	X	X		X		X	X
Road Pricing		X											X

SOURCE: RPC data supplied to DEQE

TABLE V - 4 (cont.)

MPO RACM s - RECOMMENDED FOR NON- ADOPTION (CATEGORY 3)

RACM Measures	State / EOTC	Regional Planning Commissions MAPC	MVPC	NMAC	OCPC	SRPEDD	MVC	OCPEDD	NPEDD	CMRPC	LPVRPC	BCRPC	MRPC
Improve Public Transit		X								X			
Exclusive Bus/ Carpool Lane , Area wide Carpool	X	X	X			X	X		X	X	X	X	X
Private Car Restrictions	X	X	X	X	X	X	X	X				X	X
Long Range Transit Improvements						X	X	X	X	X			
On-street Parking Controls	X							X					X
Park & Ride, Fringe Parking Lots	X												
Pedestrian Malls	X	X	X		X	X	X	X	X	X			X
Employer- based carpool/ Vanpool						X	X		X				
Bicycle lanes and Storage Facilities	X	X		X		X				X			
Variable Work Hours	X			X		X	X	X	X				
Traffic Flow Improvements	X								X				X
Road Pricing	X	X											X

SOURCE: RPC data supplied to DEQE

TABLE V - 11

MPO - ANTICIPATED NMOC EMISSION CREDITS : 1979-1982
(kg/day)

RACM Measures	MAPC	CMRPC	LPVRPC	MVPC	NMAC	OCPC	SRPEDD	MRPC	OCPEDD	MVC	BCRPC	NPEDD
Improve Public Transit	.4	.35						12.46	3.74	33.59	4.7	.48
Exclusive Bus/Carpool Lane, Area-wide Rideshare										22.39		.93
Private Car Restrictions												
Long-Range Transit Improvements												
On-Street Parking Controls	35.7									62.3		15.95
Park & Ride, Fringe Lots	14.2		.64		7.67		1.9	3.18	9.76			3.68
Pedestrian Malls												
Employer- based Carpool/ Vanpool			10.47	8.0	8.25			34.25				
Bicycle Lanes and Storage Facilities				1.5								8.07
Variable Work Hours			1.78					4.5				
Traffic Flow Improvements	566.3		16.06		2.0						8.7	
Road Pricing	39.5											
Total Emission Credits	656.5	.35	25-30	9.5	17.92	0	1-3	54.0	12-15	118	13.4	25-30

Source: RPC Data Supplied to DEQE

TABLE V - 12

MPO - ANTICIPATED TARGET NMOC REDUCTIONS BY RACM: 1987
(kg / day)

RACM Measures	Regional Planning Commissions											
	MAPC	GMRPC	LPVRPC	MVPC	NMAC	OCPC	SRPEDD	MRPC	CCPEDD	MVC	BCRPC	NPEDD
Improved Public Transit	8.0	1.0	6.08	44.8			7.5	9.36	1.57	31.44		.58
Exclusive bus/carpool lane and Area-wide Rideshare									1.51	20.96		
Private Car Restrictions												
Long-Range Transit Improvements			28.756									
On-Street Parking Contols	16.6		9.896				1.2					
Park & Ride , Fringe Lots	179.5		2.004	24.0	2.86	41.62	12.9	1.71				
Pedestrian Malls												
Employer-based Carpool/ Vanpool			35.286		4.45	2.54	1.7	10.51	1.63			
Bicycle Lanes and Storage Facilities	16.5		12.208	8.0						125.8		11.22
Variable Work Hours			.304	2.0				2.34				
Traffic Flow Improvements	900.6	27.0	7.759		29.6	14.02	10.8	11.65			25.1	
Road Pricing	150.0											
Total Target Reduction	1136.0	28	90-110	78.8	36.91	55-60	25-34	35	4-5	178		10-15

Source: RPC Data Supplied to DEQE

MPO - Anticipated Target and Actual NMHC Reductions by RACM: 1987 in Kilograms per day

Update of TABLE V-12, from the State Implementation Plan, 1982

RACM MEASURES	MAPC	CMRPC	LPVRPC	MVPC	NMAC	OCPC	SRPEDD	MRPC	CCPEDC	MVC	BCRPC	NPEDC	Statewide Totals
Improved Public Transit	8.0 / 171.9	1.0 / .35	6.08 / 33.5	44.8 / 1.1		No target set / 14.1	7.5 / 0	9.36 / 14.97	1.57 / 1.16	31.44 / 34.39	No target set / 4.7	.58 / .98	
Exclusive Bus/Carpool Lane and Area-Wide Rideshare				No target set / 8.0					1.51 / **	20.96 / 22.39		No target set / .93	
Private Car Restrictions													
Long-Range Transit Improvements			28.756 / Note 1										
On-Street Parking Controls	16.6 / 71.2		9.896 / 0				1.2 / 0			No target set / 62.3		No target set / 15.95	
Park & Ride, Fringe Lots	179.5 / 917.0		2.004 / 8.7	24.0 / 28.4	2.86 / 24.0	41.62 / 50.6	12.9 / 24.6	1.71 / 7.8	No target set / .33			No target set / 3.68	
Pedestrian Malls													
Employer Based Carpool/Vanpool	No target set / 228.2	No target set / 8.2	35.286 / 14.3	No target set / 7.9	4.46 / 13.9	2.54 / 23.2	1.7 / 43.3	10.51 / 16.8	1.63 / 10.6	No target set / 1.9			
Bicycle Lanes and Storage Facilities	16.5 / 21.6		12.208 / 13.4	8.0 / 1.5						128.8 / 11.3		11.22 / 35.87	
Variable Work Hours			.304 / **	2.0 / **				2.34 / **	No target set / .25				
Traffic Flow Improvements	900.6 / 1024.1	27.0 / 128.0	7.759 / 496.5	No target set / 23.2	29.6 / 63.4	14.02 / 14.60	10.8 / 41.44	11.65 / 7.9			25.1 / 48.16		
Road Pricing	150 / 50.6												
Total Target Reduction	1136.0 / 2,484.3	28 / 136.5	90-110 / 566.4	78.8 / 70.1	36.91 / 101.3	55-60 / 102.5	25-34 / 109.34	35 / 47.47	4-5 / 12.34	178 / 132.28	25.1 / 52.86	10-15 / 57.41	1701.8 - 1741.8 / 3,872.5

How to Read this Chart: Targeted amount / Actual Reductions

Note 1: included in "Improved Public Transit"

**Although projects in this category have been implemented, no data exist to quantify air quality changes.

Source: Original RPC Data Supplied to DEP

APPENDIX B

AIR QUALITY DATA SHEETS

ULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 1 OF 2)
:09-10-1991 TIME:19:06:02
RS/PHOENIX/DOUGLAS NO BUILD 1996
RAL CHARACTERISTICS
ROLS: STOP
AILING SPEED: 30 MPH
STREET # OF LANES: 2 LANES

R STREET LANES
OACH: C: PHOENIX EB
USIVE LEFT TURN LANES: N
USIVE RIGHT TURN LANES: N

OACH: D: DOUGLAS WB
USIVE LEFT TURN LANES: N
USIVE RIGHT TURN LANES: N

OACH	A: ROGERS NB			B: ROGERS SB			C: PHOENIX EB			D: DOUGLAS WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
ME	20	932	51	117	843	20	36	3	33	32	2	68
ENT GRADE	0.00			0.00			0.00					
CAR/HR	22			129			40	3	36	35	2	75

1 RIGHT TURNS FROM	C:PHOENIX EB	D:DOUGLAS WB
LICTING FLOWS	958	853
ICAL GAPS	6.0	6.0
CITY	304	347
ND	36	75
CITY USED	12	22
DANCE FACTOR	0.92	0.85
ED LANE	Y	Y

2 LEFT TURNS FROM	B:ROGERS SB	A:ROGERS NB
LICTING FLOWS	983	863
ICAL GAPS	5.0	5.0
CITY	435	493
ND	129	22
CITY USED	30	4
DANCE FACTOR	0.77	0.98
LABLE RESERVE	306	471
	Short traffic delay	Little or no delay
S	B	A

GIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 2 OF 2)
DATE:09-10-1991 TIME:19:00:16
ROGERS/PHOENIX/DOUGLAS NO BUILD 1991

STEP 3 THRU MOVES FROM	C:PHOENIX EB	D:DOUGLAS WB
CONFLICTING FLOWS	1731	1744
CRITICAL GAPS	7.0	7.0
CAPACITY	68	67
ADJUST FOR IMP	56	54
DEMAND	3	2
CAPACITY USED	6	4
IMPEDANCE FACTOR	0.97	0.98
SHARED LANE LEFT	Y	Y
SHARED LANE RIGHT	Y	Y

STEP 4 LEFT TURNS FROM	C:PHOENIX EB	D:DOUGLAS WB
CONFLICTING FLOWS	1793	1776
CRITICAL GAPS	7.5	7.5
CAPACITY	48	49
ADJUST FOR IMP	34	37
SHARED LANE THRU	Y	Y
SHARED LANE RIGHT	Y	Y
SHARED LN DEMAND	70	99
CAPACITY OF SHARED LN	59	95
AVAILABLE RESERVE	-11	-4
DELAY	Failure	Failure
LOS	E*	E*

SUMMARY OF LEVEL OF SERVICE BY MOVEMENT

MOVEMENT	DEMAND	CAPACITY	RESERVE	LOS
LT FROM A:	20	548	528	A
LT FROM B:	113	490	377	B
ALL MOVES FROM C:	70	59	-11	E*
ALL MOVES FROM D:	99	95	-4	E*

HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
RS/RESEARCH/PLAZA DR
D CONDITIONS 1996 PM PEAK
:09-11-1991 time:09:13:33
DATA SET NAMES LOADED OR SAVED
ME=PLZAVOL GEOMETRICS=PLZAGEO SIGNAL=PLZASIG
TED IN CBD:Y

ME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
R	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
	26	0	98	1	0	1	12.0	0.0	12.0	0
	121	0	83	1	0	1	12.0	0.0	12.0	0
	22	1165	110	1	2	0	12.0	12.0	0.0	0
	11	968	12	1	2	0	12.0	12.0	0.0	0

FIC & ROADWAY CONDITIONS

		ADJ PARK				PEDESTRIANS			ARR
GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
0.0%	1.0%	N	0	0	.900	0	N	7.0	3
0.0%	1.0%	N	0	0	.900	0	N	7.0	3
0.0%	1.0%	N	0	0	.900	0	N	7.0	3
0.0%	1.0%	N	0	0	.900	0	N	7.0	3

AINGS

EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
												*	*	*		10.0	4	A
									*	*			*	*		38.0	4	A
								*	*	*						6.0	4	A
*	*	*		*	*	*										20.0	4	A

E= 90.0

LME ADJUSTMENT WORKSHEET

1 (MOVEMENT ADJUSTMENTS)

LTV	THV	RTV	PHF	LTFR	THFR	RTFR
26	0	98	.900	29	0	109
121	0	83	.900	134	0	92
22	1165	110	.900	24	1294	122
11	968	12	.900	12	1076	13

2 (LANE GROUP ADJUSTMENTS)

LN GROUP	FLOW	N	LU	v	Plt	Prt
LT	29	1	1.00	29	1.00	0.00
RT	109	1	1.00	109	0.00	1.00
LT	134	1	1.00	134	1.00	0.00
RT	92	1	1.00	92	0.00	1.00
LT	24	1	1.00	24	1.00	0.00
TH-RT	1417	2	1.05	1488	0.00	0.09
LT	12	1	1.00	12	1.00	0.00
TH-RT	1089	2	1.05	1143	0.00	0.01

3 (OPPOSING VOLUME ADJUSTMENTS)

FT TURN		OPPOSING APPROACH									
N; OPPOSED		VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
		LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
STBOUND		134	0	92	100	100	0	1	0	1	0
TBOUND		29	0	109	100	100	0	1	0	1	0
NBOUND		12	1076	13	0	0	0	1	2	0	0
TNBOUND		24	1294	122	0	0	0	1	2	0	0

ATION FLOW ADJUSTMENT WORKSHEET

N GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
T	1800	1	1.000	0.935	1.000	1.000	1.000	0.900	1.000	0.950	1531

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
EB	90	10	1	48	43	43	0.91	1	83	0.31
WB	90	10	1	121	83	38	0.31	1	4	0.91
NB	90	65	2	1201	1201	24	0.02	2	1058	0.12

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
EB	1633	0.051	5.699	0.823	0.907	4.301	0.093	0.204	1.367	0.829	0.829
WB	1350	0.003	9.736	0.872	0.312	0.264	0.688	0.213	1.290	1.000	1.000
NB	1843	0.574	31.267	0.214	0.139	33.733	0.861	11.419	5.267	0.513	0.756

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT-TH	48	1337	0.04	0.11	149	0.32	
EB	RT	39	1370	0.03	0.11	152	0.26	
WB	LT-TH-RT	121	1305	0.09	0.11	145	0.84	*
NB	LT-TH-RT	1261	2439	0.52	0.72	1761	0.72	
SB	LT-TH-RT	1231	2221	0.55	0.80	1777	0.69	*

CYCLE= 90.0 LOST=12.0 SUM V/S CRIT= 0.65 TOTAL V/C= 0.75

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT-TH	0.32	0.11	90.0	28.02	149	0.45	0.85	24.20	C	1.1	
EB	RT	0.26	0.11	90.0	27.81	152	0.20	0.85	23.81	C	0.9	
WB	LT-TH-RT	0.84	0.11	90.0	29.79	145	21.80	0.85	43.85	E	2.8	
NB	LT-TH-RT	0.72	0.72	90.0	5.47	1761	1.00	0.85	5.49	B	8.3	
SB	LT-TH-RT	0.69	0.80	90.0	3.07	1777	0.83	0.85	3.31	A	5.9	

DIR	Delay	LOS
EB	24.03	C
WB	43.85	E
NB	5.49	B
SB	3.31	A

INTERSECTION DELAY = 6.81 INTERSECTION LOS=B

THE CYCLE LENGTH WITHIN THE BOUNDS OF 40 TO 90 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 83.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 37.6 SECONDS
for chosen cycle length 80.0
suggested timing phase 1 is 58.2 secs green, 4.0 secs yellow + red clear
suggested timing phase 2 is 9.8 secs green, 4.0 secs yellow + red clear
suggested timing phase 3 is 0.0 secs green, 4.0 secs yellow + red clear

ULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 1 OF 2)
:09-10-1991 TIME:19:08:03
RS/PHOENIX/DOUGLAS NO BUILD 1999
RAL CHARACTERISTICS
ROLS: STOP
AILING SPEED: 30 MPH
STREET # OF LANES: 2 LANES

R STREET LANES
OACH: C: PHOENIX EB
USIVE LEFT TURN LANES: N
USIVE RIGHT TURN LANES: N

OACH: D: DOUGLAS WB
USIVE LEFT TURN LANES: N
USIVE RIGHT TURN LANES: N

OACH	A: ROGERS NB			B: ROGERS SB			C: PHOENIX EB			D: DOUGLAS WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
ME	22	1004	55	125	908	22	39	4	35	34	2	73
ENT GRADE	0.00			0.00			0.00					
CAR/HR	24			138			43	4	39	37	2	80

1 RIGHT TURNS FROM	C:PHOENIX EB	D:DOUGLAS WB
LICTING FLOWS	1032	919
ICAL GAPS	6.0	6.0
CITY	277	319
ND	39	80
CITY USED	14	25
DANCE FACTOR	0.91	0.81
ED LANE	Y	Y

2 LEFT TURNS FROM	B:ROGERS SB	A:ROGERS NB
LICTING FLOWS	1059	930
ICAL GAPS	5.0	5.0
CITY	401	460
ND	138	24
CITY USED	34	5
DANCE FACTOR	0.73	0.97
LABLE RESERVE	264	435
Y	Average delay	Little or no delay
S	C	A

CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 1 OF 2)
DATE:09-10-1991 TIME:18:56:44
ROGERS/RESEARCH/STADIUM NO BUILD 1999
GENERAL CHARACTERISTICS
CONTROLS: STOP
PREVAILING SPEED: 30 MPH
MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES
APPROACH: C: RESEARCH EB
EXCLUSIVE LEFT TURN LANES: N
EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: STADIUM PLAZA
EXCLUSIVE LEFT TURN LANES: N
EXCLUSIVE RIGHT TURN LANES: N

APPROACH	A: ROGERS NB			B: ROGERS SB			C: RESEARCH EB			D: STADIUM PLA		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	24	1254	119	0	1018	12	29	6	106	131	2	89
PERCENT GRADE	0.00			0.00			0.00					
PASS CAR/HR	26			0			32	7	117	144	2	98

STEP 1 RIGHT TURNS FROM	C:RESEARCH EB	D:STADIUM PLAZA
CONFLICTING FLOWS	1314	1024
CRITICAL GAPS	6.0	6.0
CAPACITY	194	279
DEMAND	117	98
CAPACITY USED	60	35
IMPEDANCE FACTOR	0.47	0.72
SHARED LANE	Y	Y

STEP 2 LEFT TURNS FROM	B:ROGERS SB	A:ROGERS NB
CONFLICTING FLOWS	1373	1030
CRITICAL GAPS	5.0	5.0
CAPACITY	288	414
DEMAND	0	26
CAPACITY USED	0	6
IMPEDANCE FACTOR	1.00	0.96
AVAILABLE RESERVE	288	387
DELAY	Average delay	Short traffic delay
LOS	C	B

ULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 2 OF 2)
:09-10-1991 TIME:18:56:53
RS/RESEARCH/STADIUM NO BUILD 1999

3 THRU MOVES FROM	C:RESEARCH EB	D:STADIUM PLAZA
LICTING FLOWS	2368	2421
ICAL GAPS	7.0	7.0
CITY	27	25
ST FOR IMP	26	24
ND	7	2
CITY USED	26	9
DANCE FACTOR	0.81	0.94
ED LANE LEFT	Y	Y
ED LANE RIGHT	Y	Y

4 LEFT TURNS FROM	C:RESEARCH EB	D:STADIUM PLAZA
LICTING FLOWS	2459	2533
ICAL GAPS	7.5	7.5
CITY	17	15
ST FOR IMP	11	5
ED LANE THRU	Y	Y
ED LANE RIGHT	Y	Y
ED LN DEMAND	155	244
CITY OF SHARED LN	41	9
LABLE RESERVE	-114	-235
Y	Failure	Failure
	E*	E*

SUMMARY OF LEVEL OF SERVICE BY MOVEMENT

MENT	DEMAND	CAPACITY	RESERVE	LOS
ROM A:	26	414	387	B
MOVES FROM C:	155	41	-114	E*
MOVES FROM D:	244	9	-235	E*

5 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ERS/PHOENIX/DOUGLAS
LD CONDITIONS 1999 PM PEAK
e:09-11-1991 time:09:41:27
T DATA SET NAMES LOADED OR SAVED
UME=PHOVOL92 GEOMETRICS=PHOGEO SIGNAL=PHOSIG
ATED IN CBD:Y

UME & GEOMETRICS

VOLUMES			# OF LANES			LANE WIDTH			CROSS
LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
39	4	35	0	1	1	0.0	12.0	12.0	0
34	2	73	0	1	0	0.0	12.0	0.0	0
22	1004	55	0	2	0	0.0	12.0	0.0	0
125	908	22	0	2	0	0.0	12.0	0.0	0

FFIC & ROADWAY CONDITIONS

		ADJ PARK				PEDESTRIANS			ARR
GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
0.0%	1.0%	N	0	0	.900	0	N	7.0	3
0.0%	1.0%	N	0	0	.900	0	N	7.0	3
0.0%	1.0%	N	0	0	.900	0	N	7.0	3
0.0%	1.0%	N	0	0	.900	0	N	7.0	3

SINGS

EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
								*	*	*		*	*	*		65.0	4	A
*	*	*		*	*	*										10.0	4	A
												*	*	*		3.0	4	A

LE= 90.0

UME ADJUSTMENT WORKSHEET
T 1 (MOVEMENT ADJUSTMENTS)

LTV	THV	RTV	PHF	LTFR	THFR	RTFR
39	4	35	.900	43	4	39
34	2	73	.900	38	2	81
22	1004	55	.900	24	1116	61
125	908	22	.900	139	1009	24

T 2 (LANE GROUP ADJUSTMENTS)

LN GROUP	FLOW	N	LU	v	Plt	Prt
LT-TH	48	1	1.00	48	0.91	0.00
RT	39	1	1.00	39	0.00	1.00
LT-TH-RT	121	1	1.00	121	0.31	0.67
LT-TH-RT	1201	2	1.05	1261	0.02	0.05
LT-TH-RT	1172	2	1.05	1231	0.12	0.02

T 3 (OPPOSING VOLUME ADJUSTMENTS)

T TURN	OPPOSING APPROACH								
NG OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES		OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
'BOUND	38	2	81	100	100	100	0	1	0	83
'BOUND	43	4	39	100	100	0	0	1	1	4
'HBOUND	139	1009	24	90	90	90	0	2	0	1058
'HBOUND	24	1116	61	100	100	100	0	2	0	1201

'RATION FLOW ADJUSTMENT WORKSHEET

LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
LT-TH	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.829	1337
RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
LT-TH-RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.810	1.000	1305
LT-TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.756	2439
LT-TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.683	2221

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ROGERS/RESEARCH/PLAZA DR
BUILD CONDITIONS 1999 PM PEAK
date:09-11-1991 time:09:17:14
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=PLZAVOL GEOMETRICS=PLZAGEO SIGNAL=PLZASIG
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	29	0	106	1	0	1	12.0	0.0	12.0	0
WB	131	0	89	1	0	1	12.0	0.0	12.0	0
NB	24	1254	119	1	2	0	12.0	12.0	0.0	0
SB	12	1018	14	1	2	0	12.0	12.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ	PARK			PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
WB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
NB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
SB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1													*	*	*		10.0	4	A
2										*	*			*	*		38.0	4	A
3									*	*	*						6.0	4	A
4	*	*	*		*	*	*										20.0	4	A

CYCLE= 90.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	29	0	106	.900	32	0	118
WB	131	0	89	.900	146	0	99
NB	24	1254	119	.900	27	1393	132
SB	12	1018	14	.900	13	1131	16

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	32	1	1.00	32	1.00	0.00
EB	RT	118	1	1.00	118	0.00	1.00
WB	LT	146	1	1.00	146	1.00	0.00
WB	RT	99	1	1.00	99	0.00	1.00
NB	LT	27	1	1.00	27	1.00	0.00
NB	TH-RT	1526	2	1.05	1602	0.00	0.09
SB	LT	13	1	1.00	13	1.00	0.00
SB	TH-RT	1147	2	1.05	1204	0.00	0.01

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	146	0	99	100	100	0	1	0	1	0
WESTBOUND	32	0	118	100	100	0	1	0	1	0
NORTHBOUND	13	1131	16	0	0	0	1	2	0	0
SOUTHBOUND	27	1393	132	0	0	0	1	2	0	0

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1900	1	1.000	0.985	1.000	1.000	1.000	0.900	1.000	0.950	1531

RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224

CITY ANALYSIS WORKSHEET

LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
LT	32	1531	0.02	0.22	340	0.09	
RT	118	1370	0.09	0.22	304	0.39	
LT	146	1531	0.10	0.22	340	0.43	*
RT	99	1370	0.07	0.22	304	0.32	
LT	27	1531	0.02	0.07	102	0.26	*
TH-RT	1602	3224	0.50	0.53	1719	0.93	
LT	13	1531	0.01	0.11	170	0.08	
TH-RT	1204	3224	0.37	0.58	1863	0.65	*

E= 90.0 LOST=12.0 SUM V/S CRIT= 0.49 TOTAL V/C= 0.56

L OF SERVICE WORKSHEET

LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
LT	0.09	0.22	90.0	21.13	340	0.00	1.00	21.14	C	0.6	
RT	0.39	0.22	90.0	22.63	304	0.42	0.85	19.60	C	2.3	
LT	0.43	0.22	90.0	22.86	340	0.55	1.00	23.41	C	2.8	
RT	0.32	0.22	90.0	22.30	304	0.23	0.85	19.15	C	1.9	
LT	0.26	0.07	90.0	30.32	102	0.32	1.00	30.64	D	0.6	
TH-RT	0.93	0.53	90.0	14.80	1719	7.08	0.85	18.60	C	17.8	
LT	0.08	0.11	90.0	27.26	170	0.00	1.00	27.26	D	0.3	
TH-RT	0.65	0.58	90.0	9.73	1863	0.56	0.85	8.75	B	12.1	

Delay	LOS
19.93	C
21.69	C
18.80	C
8.95	B

RSECTION DELAY = 15.37 INTERSECTION LOS=C

CYCLE LENGTH WITHIN THE BOUNDS OF 30 TO 90 SECONDS
H MINIMIZES CRITICAL MOVEMENT DELAY IS 48.8 SECONDS

A V/C RATIO OF .95 THE CYCLE SHOULD BE 24.6 SECONDS
chosen cycle length 50.0
ested timing phase 1 is 0.7 secs green, 4.0 secs yellow + red clear
ested timing phase 2 is 28.5 secs green, 4.0 secs yellow + red clear
ested timing phase 3 is 1.4 secs green, 4.0 secs yellow + red clear
ested timing phase 4 is 7.4 secs green, 4.0 secs yellow + red clear

CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 2 OF 2)
DATE:09-10-1991 TIME:19:08:10
ROGERS/PHOENIX/DOUGLAS NO BUILD 1999

STEP 3 THRU MOVES FROM	C:PHOENIX EB	D:DOUGLAS WB
CONFLICTING FLOWS	2109	2125
CRITICAL GAPS	7.0	7.0
CAPACITY	39	38
ADJUST FOR IMP	28	27
DEMAND	4	2
CAPACITY USED	16	8
IMPEDANCE FACTOR	0.89	0.95
SHARED LANE LEFT	Y	Y
SHARED LANE RIGHT	Y	Y

STEP 4 LEFT TURNS FROM	C:PHOENIX EB	D:DOUGLAS WB
CONFLICTING FLOWS	2184	2164
CRITICAL GAPS	7.5	7.5
CAPACITY	26	27
ADJUST FOR IMP	14	15
SHARED LANE THRU	Y	Y
SHARED LANE RIGHT	Y	Y
SHARED LN DEMAND	86	120
CAPACITY OF SHARED LN	26	43
AVAILABLE RESERVE	-60	-77
DELAY	Failure	Failure
LOS	E*	E*

SUMMARY OF LEVEL OF SERVICE BY MOVEMENT

MOVEMENT	DEMAND	CAPACITY	RESERVE	LOS
LT FROM A:	24	460	435	A
LT FROM B:	138	401	264	C
ALL MOVES FROM C:	86	26	-60	E*
ALL MOVES FROM D:	120	43	-77	E*

HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
RS/PHOENIX/DOUGLAS
D CONDITIONS 1996 PM PEAK
:09-11-1991 time:09:37:44
DATA SET NAMES LOADED OR SAVED
ME=PHOVOL92 GEOMETRICS=PHOGEO SIGNAL=PHOSIG
TED IN CBD:Y
ME & GEOMETRICS

VOLUMES			# OF LANES			LANE WIDTH			CROSS
LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
36	3	33	0	1	1	0.0	12.0	12.0	0
32	2	68	0	1	0	0.0	12.0	0.0	0
20	932	51	0	2	0	0.0	12.0	0.0	0
117	843	20	0	2	0	0.0	12.0	0.0	0

FIC & ROADWAY CONDITIONS

GRADE	%HV	ADJ PARK Y/N	MOVES	BUSES	PHF	PEDESTRIANS CROSS	BUT	MIN	ARR TIME	TYPE
0.0%	1.0%	N	0	0	.900	0	N		7.0	3
0.0%	1.0%	N	0	0	.900	0	N		7.0	3
0.0%	1.0%	N	0	0	.900	0	N		7.0	3
0.0%	1.0%	N	0	0	.900	0	N		7.0	3

INGS

EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
								*	*	*		*	*	*		65.0	4	A
*	*	*		*	*	*										10.0	4	A
												*	*	*		3.0	4	A

E= 90.0

ME ADJUSTMENT WORKSHEET
R 1 (MOVEMENT ADJUSTMENTS)

LTV	THV	RTV	PHF	LTFR	THFR	RTFR
36	3	33	.900	40	3	37
32	2	68	.900	36	2	76
20	932	51	.900	22	1036	57
117	843	20	.900	130	937	22

R 2 (LANE GROUP ADJUSTMENTS)

LN GROUP	FLOW	N	LU	v	Plt	Prt
LT-TH	43	1	1.00	43	0.92	0.00
RT	37	1	1.00	37	0.00	1.00
LT-TH-RT	113	1	1.00	113	0.31	0.67
LT-TH-RT	1114	2	1.05	1170	0.02	0.05
LT-TH-RT	1089	2	1.05	1143	0.12	0.02

3 (OPPOSING VOLUME ADJUSTMENTS)

TURN G OPPOSED	OPPOSING APPROACH VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
BOUND	36	2	76	100	100	100	0	1	0	78
BOUND	40	3	37	100	100	0	0	1	1	3
HBOUND	130	937	22	90	90	90	0	2	0	983
HBOUND	22	1036	57	100	100	100	0	2	0	1114

RATION FLOW ADJUSTMENT WORKSHEET

LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
LT-TH	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.851	1372
RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
LT-TH-RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.810	1.000	1306
LT-TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.867	2794
LT-TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	[illegible]	[illegible]	[illegible]

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
EB	90	10	1	43	40	40	0.92	1	78	0.31
WB	90	10	1	113	78	36	0.31	1	3	0.92
NB	90	65	2	1114	1114	22	0.02	2	983	0.12

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
EB	1634	0.048	6.002	0.826	0.923	3.998	0.077	0.166	1.361	0.851	0.851
WB	1350	0.002	9.802	0.873	0.314	0.198	0.686	0.160	1.289	1.000	1.000
NB	2204	0.446	44.877	0.261	0.100	20.123	0.900	11.766	4.317	0.733	0.867

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT-TH	43	1372	0.03	0.11	152	0.28	
EB	RT	37	1370	0.03	0.11	152	0.24	
WB	LT-TH-RT	113	1306	0.09	0.11	145	0.78	*
NB	LT-TH-RT	1170	2794	0.42	0.72	2018	0.58	
SB	LT-TH-RT	1143	2478	0.46	0.80	1983	0.58	*

CYCLE= 90.0 LOST=12.0 SUM V/S CRIT= 0.55 TOTAL V/C= 0.63

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT-TH	0.28	0.11	90.0	27.90	152	0.29	0.85	23.96	C	1.0	
EB	RT	0.24	0.11	90.0	27.77	152	0.17	0.85	23.74	C	0.8	
WB	LT-TH-RT	0.78	0.11	90.0	29.59	145	15.55	0.85	38.37	D	2.5	
NB	LT-TH-RT	0.58	0.72	90.0	4.54	2018	0.32	0.85	4.13	A	7.7	
SB	LT-TH-RT	0.58	0.80	90.0	2.54	1983	0.31	0.85	2.43	A	5.4	

DIR	Delay	LOS
EB	23.86	C
WB	38.37	D
NB	4.13	A
SB	2.43	A

INTERSECTION DELAY = 5.53 INTERSECTION LOS=B

THE CYCLE LENGTH WITHIN THE BOUNDS OF 40 TO 90 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 64.2 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 28.4 SECONDS
for chosen cycle length 65.0
suggested timing phase 1 is 44.6 secs green, 4.0 secs yellow + red clear
suggested timing phase 2 is 8.4 secs green, 4.0 secs yellow + red clear
suggested timing phase 3 is 0.0 secs green, 4.0 secs yellow + red clear

RCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 2 OF 2)
TE:09-10-1991 TIME:19:06:10
GERS/PHOENIX/DOUGLAS NO BUILD 1996

EP 3 THRU MOVES FROM	C:PHOENIX EB	D:DOUGLAS WB
NFLICTING FLOWS	1958	1973
ITICAL GAPS	7.0	7.0
PACITY	49	48
JUST FOR IMP	37	36
MAND	3	2
PACITY USED	9	6
PEDANCE FACTOR	0.95	0.97
ARED LANE LEFT	Y	Y
ARED LANE RIGHT	Y	Y

EP 4 LEFT TURNS FROM	C:PHOENIX EB	D:DOUGLAS WB
FLICTING FLOWS	2028	2009
ITICAL GAPS	7.5	7.5
PACITY	33	34
UST FOR IMP	20	23
ARED LANE THRU	Y	Y
ARED LANE RIGHT	Y	Y
RED LN DEMAND	79	112
ACITY OF SHARED LN	37	61
AILABLE RESERVE	-42	-51
AY	Failure	Failure
	E*	E*

SUMMARY OF LEVEL OF SERVICE BY MOVEMENT

EMENT	DEMAND	CAPACITY	RESERVE	LOS
FROM A:	22	493	471	A
FROM B:	129	435	306	B
MOVES FROM C:	79	37	-42	E*
MOVES FROM D:	112	61	-51	E*

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ROGERS/PHOENIX/DOUGLAS
BUILD CONDITIONS 1995 PM PEAK
date:09-11-1991 time:09:34:18
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=PHOVOL92 GEOMETRICS=PHOGEO SIGNAL=PHOSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	35	3	32	0	1	1	0.0	12.0	12.0	0
WB	31	2	66	0	1	0	0.0	12.0	0.0	0
NB	20	910	50	0	2	0	0.0	12.0	0.0	0
SB	114	822	20	0	2	0	0.0	12.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
WB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
NB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
SB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1									*	*	*		*	*	*		65.0	4	A
2	*	*	*		*	*	*										10.0	4	A
3													*	*	*		3.0	4	A

CYCLE= 90.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	35	3	32	.900	39	3	36
WB	31	2	66	.900	34	2	73
NB	20	910	50	.900	22	1011	56
SB	114	822	20	.900	127	913	22

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT-TH	42	1	1.00	42	0.92	0.00
EB	RT	36	1	1.00	36	0.00	1.00
WB	LT-TH-RT	110	1	1.00	110	0.31	0.67
NB	LT-TH-RT	1089	2	1.05	1143	0.02	0.05
SB	LT-TH-RT	1062	2	1.05	1115	0.12	0.02

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	34	2	73	100	100	100	0	1	0	76
WESTBOUND	39	3	36	100	100	0	0	1	1	3
NORTHBOUND	127	913	22	0	90	90	0	2	0	845
SOUTHBOUND	22	1011	56	100	100	100	0	2	0	1089

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT-TH	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.861	1389
EB	RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
WB	LT-TH-RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.810	1.000	1306
NB	LT-TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.943	3041
SB	LT-TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.786	[illegible]

PPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

PUT VARIABLES

R	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
	90	10	1	42	39	39	0.92	1	76	0.31
	90	10	1	110	76	34	0.31	1	3	0.92
	90	65	2	1089	1089	22	0.02	2	845	0.00

LCULATIONS

R	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
	1635	0.046	6.124	0.828	0.921	3.876	0.079	0.170	1.359	0.861	0.861
	1353	0.002	9.802	0.873	0.313	0.198	0.687	0.160	1.289	1.000	1.000
	3600	0.235	57.337	0.347	0.075	7.663	0.925	6.373	3.241	0.887	0.943

PACITY ANALYSIS WORKSHEET

R	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
	LT-TH	42	1389	0.03	0.11	154	0.27	
	RT	36	1370	0.03	0.11	152	0.23	
	LT-TH-RT	110	1306	0.08	0.11	145	0.76	*
	LT-TH-RT	1143	3041	0.38	0.72	2196	0.52	
	LT-TH-RT	1115	2535	0.44	0.80	2028	0.55	*

CLE= 90.0 LOST=12.0 SUM V/S CRIT= 0.52 TOTAL V/C= 0.60

VEL OF SERVICE WORKSHEET

R	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
	LT-TH	0.27	0.11	90.0	27.87	154	0.25	0.85	23.90	C	0.9	
	RT	0.23	0.11	90.0	27.74	152	0.15	0.85	23.71	C	0.8	
	LT-TH-RT	0.76	0.11	90.0	29.51	145	13.44	0.85	36.51	D	2.4	
	LT-TH-RT	0.52	0.72	90.0	4.23	2196	0.18	0.85	3.75	A	7.6	
	LT-TH-RT	0.55	0.80	90.0	2.44	2028	0.25	0.85	2.29	A	5.3	

R	Delay	LOS
	23.81	C
	36.51	D
	3.75	A
	2.29	A

TERSECTION DELAY = 5.20 INTERSECTION LOS=B

E CYCLE LENGTH WITHIN THE BOUNDS OF 30 TO 90 SECONDS
ICH MINIMIZES CRITICAL MOVEMENT DELAY IS 60.7 SECONDS

R A V/C RATIO OF .95 THE CYCLE SHOULD BE 26.8 SECONDS
r chosen cycle length 60.0
ggested timing phase 1 is 40.3 secs green, 4.0 secs yellow + red clear
ggested timing phase 2 is 7.7 secs green, 4.0 secs yellow + red clear
ggested timing phase 3 is 0.0 secs green, 4.0 secs yellow + red clear

CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 1 OF 2)
DATE:09-10-1991 TIME:19:03:50
ROGERS/PHOENIX/DOUGLAS NO BUILD 1995
GENERAL CHARACTERISTICS
CONTROLS: STOP
PREVAILING SPEED: 30 MPH
MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES
APPROACH: C: PHOENIX EB
EXCLUSIVE LEFT TURN LANES: N
EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: DOUGLAS WB
EXCLUSIVE LEFT TURN LANES: N
EXCLUSIVE RIGHT TURN LANES: N

APPROACH	A: ROGERS NB			B: ROGERS SB			C: PHOENIX EB			D: DOUGLAS WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	20	910	50	114	822	20	35	3	32	31	2	66
PERCENT GRADE	0.00			0.00			0.00					
PASS CAR/HR	22			125			39	3	35	34	2	73

STEP 1 RIGHT TURNS FROM	C:PHOENIX EB	D:DOUGLAS WB
CONFLICTING FLOWS	935	832
CRITICAL GAPS	6.0	6.0
CAPACITY	313	356
DEMAND	35	73
CAPACITY USED	11	20
IMPEDANCE FACTOR	0.93	0.86
SHARED LANE	Y	Y

STEP 2 LEFT TURNS FROM	B:ROGERS SB	A:ROGERS NB
CONFLICTING FLOWS	960	842
CRITICAL GAPS	5.0	5.0
CAPACITY	445	504
DEMAND	125	22
CAPACITY USED	28	4
IMPEDANCE FACTOR	0.79	0.98
AVAILABLE RESERVE	320	482
DELAY	Short traffic delay	Little or no delay
LOS	B	A

CULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 2 OF 2)
E:09-10-1991 TIME:19:03:58
ERS/PHOENIX/DOUGLAS NO BUILD 1995

P 3 THRU MOVES FROM	C:PHOENIX EB	D:DOUGLAS WB
FLICTING FLOWS	1911	1926
TICAL GAPS	7.0	7.0
ACITY	52	51
UST FOR IMP	40	39
AND	3	2
ACITY USED	8	6
EDANCE FACTOR	0.95	0.97
RED LANE LEFT	Y	Y
RED LANE RIGHT	Y	Y

P 4 LEFT TURNS FROM	C:PHOENIX EB	D:DOUGLAS WB
FLICTING FLOWS	1979	1961
TICAL GAPS	7.5	7.5
ACITY	36	37
UST FOR IMP	23	25
RED LANE THRU	Y	Y
RED LANE RIGHT	Y	Y
RED LN DEMAND	77	109
ACITY OF SHARED LN	41	67
ILABLE RESERVE	-36	-42
AY	Failure	Failure
	E*	E*

SUMMARY OF LEVEL OF SERVICE BY MOVEMENT

EMENT	DEMAND	CAPACITY	RESERVE	LOS
FROM A:	22	504	482	A
FROM B:	125	445	320	B
MOVES FROM C:	77	41	-36	E*
MOVES FROM D:	109	67	-42	E*

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ROGERS/PHOENIX/DOUGLAS
BUILD YEAR 1992 PM PEAK
date:09-11-1991 time:09:30:11
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=PHOVOL92 GEOMETRICS=PHOGEO SIGNAL=PHOSIG
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	32	3	29	0	1	1	0.0	12.0	12.0	0
WB	28	2	60	0	1	0	0.0	12.0	0.0	0
NB	18	845	46	0	2	0	0.0	12.0	0.0	0
SB	106	764	18	0	2	0	0.0	12.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
WB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
NB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
SB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1									*	*	*		*	*	*		65.0	4	A
2	*	*	*		*	*	*										10.0	4	A
3													*	*	*		3.0	4	A

CYCLE= 90.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	32	3	29	.900	36	3	32
WB	28	2	60	.900	31	2	67
NB	18	845	46	.900	20	939	51
SB	106	764	18	.900	118	849	20

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT-TH	39	1	1.00	39	0.91	0.00
EB	RT	32	1	1.00	32	0.00	1.00
WB	LT-TH-RT	100	1	1.00	100	0.31	0.67
NB	LT-TH-RT	1010	2	1.05	1061	0.02	0.05
SB	LT-TH-RT	987	2	1.05	1036	0.12	0.02

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	31	2	67	100	100	100	0	1	0	69
WESTBOUND	36	3	32	100	100	0	0	1	1	3
NORTHBOUND	118	849	20	90	90	90	0	2	0	891
SOUTHBOUND	20	939	51	100	100	100	0	2	0	1010

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT-TH	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.892	1438
EB	RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
WB	LT-TH-RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.810	1.000	1306
NB	LT-TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.920	2966
SB	LT-TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.829	2672

PLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

UT VARIABLES

C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
90	10	1	39	36	36	0.91	1	69	0.31
90	10	1	100	69	31	0.31	1	3	0.91
90	65	2	1010	1010	20	0.02	2	891	0.12

CULATIONS

Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
1637	0.042	6.486	0.832	0.914	3.514	0.086	0.185	1.352	0.892	0.892
1362	0.002	9.804	0.873	0.311	0.196	0.689	0.159	1.289	1.000	1.000
2515	0.354	51.288	0.318	0.082	13.712	0.918	9.952	3.535	0.840	0.920

ACITY ANALYSIS WORKSHEET

LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
LT-TH	39	1438	0.03	0.11	160	0.24	
RT	32	1370	0.02	0.11	152	0.21	
LT-TH-RT	100	1306	0.08	0.11	145	0.69	*
LT-TH-RT	1061	2966	0.36	0.72	2142	0.50	
LT-TH-RT	1036	2672	0.39	0.80	2138	0.48	*

LE= 90.0 LOST=12.0 SUM V/S CRIT= 0.46 TOTAL V/C= 0.54

EL OF SERVICE WORKSHEET

LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
LT-TH	0.24	0.11	90.0	27.77	160	0.16	0.85	23.75	C	0.9	
RT	0.21	0.11	90.0	27.67	152	0.11	0.85	23.61	C	0.7	
LT-TH-RT	0.69	0.11	90.0	29.26	145	8.61	0.85	32.19	D	2.2	
LT-TH-RT	0.50	0.72	90.0	4.11	2142	0.15	0.85	3.62	A	7.0	
LT-TH-RT	0.48	0.80	90.0	2.23	2138	0.14	0.85	2.02	A	4.9	

Delay	LOS
23.69	C
32.19	D
3.62	A
2.02	A

ERSECTION DELAY = 4.78 INTERSECTION LOS=A

CYCLE LENGTH WITHIN THE BOUNDS OF 30 TO 90 SECONDS
CH MINIMIZES CRITICAL MOVEMENT DELAY IS 53.7 SECONDS

A V/C RATIO OF .95 THE CYCLE SHOULD BE 23.5 SECONDS
chosen cycle length 55.0
gested timing phase 1 is 35.9 secs green, 4.0 secs yellow + red clear
gested timing phase 2 is 7.1 secs green, 4.0 secs yellow + red clear
gested timing phase 3 is 0.0 secs green, 4.0 secs yellow + red clear

CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 1 OF 2)
DATE:09-10-1991 TIME:19:00:08
ROGERS/PHOENIX/DOUGLAS NO BUILD 1991
GENERAL CHARACTERISTICS
CONTROLS: STOP
PREVAILING SPEED: 30 MPH
MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES
APPROACH: C: PHOENIX EB
EXCLUSIVE LEFT TURN LANES: N
EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: DOUGLAS WB
EXCLUSIVE LEFT TURN LANES: N
EXCLUSIVE RIGHT TURN LANES: N

APPROACH	A: ROGERS NB			B: ROGERS SB			C: PHOENIX EB			D: DOUGLAS WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	18	824	45	103	745	18	32	3	29	28	2	60
PERCENT GRADE	0.00			0.00			0.00					
PASS CAR/HR	20			113			35	3	32	31	2	66

STEP 1 RIGHT TURNS FROM	C:PHOENIX EB	D:DOUGLAS WB
CONFLICTING FLOWS	847	754
CRITICAL GAPS	6.0	6.0
CAPACITY	350	393
DEMAND	32	66
CAPACITY USED	9	17
IMPEDANCE FACTOR	0.95	0.89
SHARED LANE	Y	Y

STEP 2 LEFT TURNS FROM	B:ROGERS SB	A:ROGERS NB
CONFLICTING FLOWS	869	763
CRITICAL GAPS	5.0	5.0
CAPACITY	490	548
DEMAND	113	20
CAPACITY USED	23	4
IMPEDANCE FACTOR	0.83	0.98
AVAILABLE RESERVE	377	528
DELAY	Short traffic delay	Little or no delay
LOS	B	A

RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224

PACITY ANALYSIS WORKSHEET

R LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
LT	29	1531	0.02	0.22	340	0.08	
RT	109	1370	0.08	0.22	304	0.36	
LT	134	1531	0.09	0.22	340	0.40	*
RT	92	1370	0.07	0.22	304	0.30	
LT	24	1531	0.02	0.07	102	0.24	*
TH-RT	1488	3224	0.46	0.53	1719	0.87	
LT	12	1531	0.01	0.11	170	0.07	
TH-RT	1143	3224	0.35	0.58	1863	0.61	*

CLE= 90.0 LOST=12.0 SUM V/S CRIT= 0.46 TOTAL V/C= 0.53

VEL OF SERVICE WORKSHEET

R LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
LT	0.08	0.22	90.0	21.09	340	0.00	1.00	21.09	C	0.6	
RT	0.36	0.22	90.0	22.48	304	0.32	0.85	19.38	C	2.1	
LT	0.40	0.22	90.0	22.68	340	0.41	1.00	23.09	C	2.6	
RT	0.30	0.22	90.0	22.18	304	0.18	0.85	19.01	C	1.8	
LT	0.24	0.07	90.0	30.28	102	0.24	1.00	30.52	D	0.6	
TH-RT	0.87	0.53	90.0	13.83	1719	3.51	0.85	14.74	B	16.5	
LT	0.07	0.11	90.0	27.24	170	0.00	1.00	27.24	D	0.3	
TH-RT	0.61	0.58	90.0	9.45	1863	0.44	0.85	8.41	B	11.5	

R Delay	LOS
19.74	C
21.43	C
14.99	B
8.60	B

TERSECTION DELAY = 13.26 INTERSECTION LOS=B

CYCLE LENGTH WITHIN THE BOUNDS OF 30 TO 60 SECONDS
CH MINIMIZES CRITICAL MOVEMENT DELAY IS 46.5 SECONDS

R A V/C RATIO OF .95 THE CYCLE SHOULD BE 23.2 SECONDS
chosen cycle length 50.0
ggested timing phase 1 is 0.7 secs green, 4.0 secs yellow + red clear
ggested timing phase 2 is 28.7 secs green, 4.0 secs yellow + red clear
ggested timing phase 3 is 1.3 secs green, 4.0 secs yellow + red clear
ggested timing phase 4 is 7.3 secs green, 4.0 secs yellow + red clear

CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 1 OF 2)
DATE:09-10-1991 TIME:18:54:48
ROGERS/RESEARCH/STADIUM NO BUILD 1996
GENERAL CHARACTERISTICS
CONTROLS: STOP
PREVAILING SPEED: 30 MPH
MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES
APPROACH: C: RESEARCH EB
EXCLUSIVE LEFT TURN LANES: N
EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: STADIUM PLAZA
EXCLUSIVE LEFT TURN LANES: N
EXCLUSIVE RIGHT TURN LANES: N

APPROACH	A: ROGERS NB			B: ROGERS SB			C: RESEARCH EB			D: STADIUM PLA		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	22	1165	110	0	945	11	26	6	98	121	2	83
PERCENT GRADE	0.00			0.00			0.00					
PASS CAR/HR	24			0			29	7	108	133	2	91

STEP 1 RIGHT TURNS FROM	C:RESEARCH EB	D:STADIUM PLAZA
CONFLICTING FLOWS	1220	951
CRITICAL GAPS	6.0	6.0
CAPACITY	218	307
DEMAND	108	91
CAPACITY USED	49	30
IMPEDANCE FACTOR	0.58	0.77
SHARED LANE	Y	Y

STEP 2 LEFT TURNS FROM	B:ROGERS SB	A:ROGERS NB
CONFLICTING FLOWS	1275	956
CRITICAL GAPS	5.0	5.0
CAPACITY	319	447
DEMAND	0	24
CAPACITY USED	0	5
IMPEDANCE FACTOR	1.00	0.97
AVAILABLE RESERVE	319	423
DELAY	Short traffic delay	Little or no delay
LOS	B	A

:CULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 2 OF 2)
'E:09-10-1991 TIME:18:54:57
;ERS/RESEARCH/STADIUM NO BUILD 1996

:P 3 THRU MOVES FROM	C:RESEARCH EB	D:STADIUM PLAZA
'FLICTING FLOWS	2198	2248
:TICAL GAPS	7.0	7.0
'ACITY	34	32
'UST FOR IMP	33	31
IAND	7	2
'ACITY USED	20	7
'EDANCE FACTOR	0.86	0.96
\RED LANE LEFT	Y	Y
\RED LANE RIGHT	Y	Y

:P 4 LEFT TURNS FROM	C:RESEARCH EB	D:STADIUM PLAZA
'FLICTING FLOWS	2283	2352
:TICAL GAPS	7.5	7.5
'ACITY	22	20
'UST FOR IMP	16	10
\RED LANE THRU	Y	Y
\RED LANE RIGHT	Y	Y
\RED LN DEMAND	143	227
'ACITY OF SHARED LN	57	16
\ILABLE RESERVE	-86	-211
.AY	Failure	Failure
;	E*	E*

SUMMARY OF LEVEL OF SERVICE BY MOVEMENT

'EMENT	DEMAND	CAPACITY	RESERVE	LOS
FROM A:	24	447	423	A
. MOVES FROM C:	143	57	-86	E*
. MOVES FROM D:	227	16	-211	E*

2 lc
34320

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ROGERS/RESEARCH/PLAZA DR
BUILD CONDITIONS 1995 PM PEAK
date:09-11-1991 time:09:09:53
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=PLZAVOL GEOMETRICS=PLZAGEO SIGNAL=PLZASIG
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	26	0	96	1	0	1	12.0	0.0	12.0	0
WB	118	0	81	1	0	1	12.0	0.0	12.0	0
NB	22	1136	108	1	2	0	12.0	12.0	0.0	0
SB	11	945	12	1	2	0	12.0	12.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
WB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
NB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
SB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1													*	*	*		10.0	4	A
2										*	*			*	*		38.0	4	A
3									*	*	*						6.0	4	A
4	*	*	*		*	*	*										20.0	4	A

CYCLE= 90.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	26	0	96	.900	29	0	107
WB	118	0	81	.900	131	0	90
NB	22	1136	108	.900	24	1262	120
SB	11	945	12	.900	12	1050	13

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	29	1	1.00	29	1.00	0.00
EB	RT	107	1	1.00	107	0.00	1.00
WB	LT	131	1	1.00	131	1.00	0.00
WB	RT	90	1	1.00	90	0.00	1.00
NB	LT	24	1	1.00	24	1.00	0.00
NB	TH-RT	1382	2	1.05	1451	0.00	0.09
SB	LT	12	1	1.00	12	1.00	0.00
SB	TH-RT	1063	2	1.05	1117	0.00	0.01

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	131	0	90	100	100	0	1	0	1	0
WESTBOUND	29	0	107	100	100	0	1	0	1	0
NORTHBOUND	12	1050	13	0	0	0	1	2	0	0
SOUTHBOUND	24	1262	120	0	0	0	1	2	0	0

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1900	1	1.000	0.985	1.000	1.000	1.000	0.900	1.000	0.950	1531

RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224

PACITY ANALYSIS WORKSHEET

R LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
LT	29	1531	0.02	0.22	340	0.08	
RT	107	1370	0.08	0.22	304	0.35	
LT	131	1531	0.09	0.22	340	0.39	*
RT	90	1370	0.07	0.22	304	0.30	
LT	24	1531	0.02	0.07	102	0.24	*
TH-RT	1451	3224	0.45	0.53	1719	0.84	
LT	12	1531	0.01	0.11	170	0.07	
TH-RT	1117	3224	0.35	0.58	1863	0.60	*

CLE= 90.0 LOST=12.0 SUM V/S CRIT= 0.45 TOTAL V/C= 0.52

VEL OF SERVICE WORKSHEET

R LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
LT	0.08	0.22	90.0	21.09	340	0.00	1.00	21.09	C	0.6	
RT	0.35	0.22	90.0	22.44	304	0.30	0.85	19.32	C	2.1	
LT	0.39	0.22	90.0	22.63	340	0.37	1.00	23.00	C	2.5	
RT	0.30	0.22	90.0	22.14	304	0.17	0.85	18.96	C	1.8	
LT	0.24	0.07	90.0	30.28	102	0.24	1.00	30.52	D	0.6	
TH-RT	0.84	0.53	90.0	13.55	1719	2.89	0.85	13.97	B	16.1	
LT	0.07	0.11	90.0	27.24	170	0.00	1.00	27.24	D	0.3	
TH-RT	0.60	0.58	90.0	9.33	1863	0.40	0.85	8.26	B	11.2	

R Delay	LOS
19.70	C
21.36	C
14.24	B
8.47	B

TERSECTION DELAY = 12.82 INTERSECTION LOS=B

E CYCLE LENGTH WITHIN THE BOUNDS OF 30 TO 120 SECONDS
ICH MINIMIZES CRITICAL MOVEMENT DELAY IS 45.6 SECONDS

R A V/C RATIO OF .95 THE CYCLE SHOULD BE 22.7 SECONDS
: chosen cycle length 45.0
ggested timing phase 1 is 0.6 secs green, 4.0 secs yellow + red clear
ggested timing phase 2 is 24.9 secs green, 4.0 secs yellow + red clear
ggested timing phase 3 is 1.2 secs green, 4.0 secs yellow + red clear
ggested timing phase 4 is 6.3 secs green, 4.0 secs yellow + red clear

CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 1 OF 2)
DATE:09-10-1991 TIME:18:52:23
ROGERS/RESEARCH/STADIUM NO BUILD 1995
GENERAL CHARACTERISTICS
CONTROLS: STOP
PREVAILING SPEED: 30 MPH
MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES
APPROACH: C: LOWELL RESEARC
EXCLUSIVE LEFT TURN LANES: N
EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: STADIUM PLAZA
EXCLUSIVE LEFT TURN LANES: N
EXCLUSIVE RIGHT TURN LANES: N

APPROACH	A: ROGERS NB			B: ROGERS SB			C: LOWELL RESE			D: STADIUM PLA		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	22	1136	108	0	922	11	26	5	96	118	2	81
PERCENT GRADE	0.00			0.00			0.00					
PASS CAR/HR	24			0			29	6	106	130	2	89

STEP 1 RIGHT TURNS FROM	C:LOWELL RESEARC	D:STADIUM PLAZA
CONFLICTING FLOWS	1190	928
CRITICAL GAPS	6.0	6.0
CAPACITY	227	316
DEMAND	106	89
CAPACITY USED	47	28
IMPEDANCE FACTOR	0.61	0.79
SHARED LANE	Y	Y

STEP 2 LEFT TURNS FROM	B:ROGERS SB	A:ROGERS NB
CONFLICTING FLOWS	1244	933
CRITICAL GAPS	5.0	5.0
CAPACITY	330	458
DEMAND	0	24
CAPACITY USED	0	5
IMPEDANCE FACTOR	1.00	0.97
AVAILABLE RESERVE	330	434
DELAY	Short traffic delay	Little or no delay
LOS	B	A

CULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 2 OF 2)
E:09-10-1991 TIME:18:52:31
ERS/RESEARCH/STADIUM NO BUILD 1995

P 3 THRU MOVES FROM	C:LOWELL RESEARC	D:STADIUM PLAZA
FLICTING FLOWS	2145	2194
TICAL GAPS	7.0	7.0
ACITY	37	34
UST FOR IMP	36	33
AND	6	2
ACITY USED	15	7
EDANCE FACTOR	0.90	0.96
RED LANE LEFT	Y	Y
RED LANE RIGHT	Y	Y

P 4 LEFT TURNS FROM	C:LOWELL RESEARC	D:STADIUM PLAZA
FLICTING FLOWS	2228	2295
TICAL GAPS	7.5	7.5
ACITY	24	22
UST FOR IMP	18	12
RED LANE THRU	Y	Y
RED LANE RIGHT	Y	Y
RED LN DEMAND	140	221
ACITY OF SHARED LN	63	19
ILABLE RESERVE	-77	-202
AY	Failure	Failure
	E*	E*

SUMMARY OF LEVEL OF SERVICE BY MOVEMENT

EMENT	DEMAND	CAPACITY	RESERVE	LOS		
FROM A:	24	458	434	A	5	216
MOVES FROM C:	140	63	-77	E*	240	33600
MOVES FROM D:	221	19	-202	E*	265	53040
						86856

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ROGERS/RESEARCH/PLAZA DR
BUILD YEAR 1992 PM PEAK
date:09-11-1991 time:09:04:17
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=PLZAVOL GEOMETRICS=PLZAGEO SIGNAL=PLZASIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	24	0	89	1	0	1	12.0	0.0	12.0	0
WB	110	0	75	1	0	1	12.0	0.0	12.0	0
NB	20	1055	0	1	2	0	12.0	12.0	0.0	0
SB	10	856	10	1	2	0	12.0	12.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
WB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
NB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
SB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1													*	*	*		10.0	4	A
2										*	*			*	*		38.0	4	A
3									*	*	*						6.0	4	A
4	*	*	*		*	*	*										20.0	4	A

CYCLE= 90.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	24	0	89	.900	27	0	99
WB	110	0	75	.900	122	0	83
NB	20	1055	0	.900	22	1172	0
SB	10	856	10	.900	11	951	11

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	27	1	1.00	27	1.00	0.00
EB	RT	99	1	1.00	99	0.00	1.00
WB	LT	122	1	1.00	122	1.00	0.00
WB	RT	83	1	1.00	83	0.00	1.00
NB	LT	22	1	1.00	22	1.00	0.00
NB	TH	1172	2	1.05	1231	0.00	0.00
SB	LT	11	1	1.00	11	1.00	0.00
SB	TH-RT	962	2	1.05	1010	0.00	0.01

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	122	0	83	100	100	0	1	0	1	0
WESTBOUND	27	0	99	100	100	0	1	0	1	0
NORTHBOUND	11	951	11	0	0	0	1	2	0	0
SOUTHBOUND	22	1172	0	0	0	0	1	2	0	0

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
EB	RT	[illegible]	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370

LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
TH	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
TH-RT	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224

'ACITY ANALYSIS WORKSHEET

LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
LT	27	1531	0.02	0.22	340	0.08	
RT	99	1370	0.07	0.22	304	0.32	
LT	122	1531	0.08	0.22	340	0.36	*
RT	83	1370	0.06	0.22	304	0.27	
LT	22	1531	0.01	0.07	102	0.22	*
TH	1231	3224	0.38	0.53	1719	0.72	
LT	11	1531	0.01	0.11	170	0.07	
TH-RT	1010	3224	0.31	0.58	1863	0.54	*

:LE= 90.0 LOST=12.0 SUM V/S CRIT= 0.41 TOTAL V/C= 0.47

'EL OF SERVICE WORKSHEET

LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
LT	0.08	0.22	90.0	21.06	340	0.00	1.00	21.06	C	0.5	
RT	0.32	0.22	90.0	22.30	304	0.23	0.85	19.15	C	1.9	
LT	0.36	0.22	90.0	22.48	340	0.29	1.00	22.77	C	2.4	
RT	0.27	0.22	90.0	22.03	304	0.13	0.85	18.83	C	1.6	
LT	0.22	0.07	90.0	30.23	102	0.18	1.00	30.41	D	0.5	
TH	0.72	0.53	90.0	12.05	1719	1.02	0.85	11.11	B	13.7	
LT	0.07	0.11	90.0	27.22	170	0.00	1.00	27.22	D	0.2	
TH-RT	0.54	0.58	90.0	8.88	1863	0.26	0.85	7.77	B	10.2	

Delay	LOS
19.55	C
21.18	C
11.45	B
7.98	B

'ERSECTION DELAY = 11.25 INTERSECTION LOS=B

: CYCLE LENGTH WITHIN THE BOUNDS OF 30 TO 120 SECONDS
:CH MINIMIZES CRITICAL MOVEMENT DELAY IS 41.9 SECONDS

: A V/C RATIO OF .95 THE CYCLE SHOULD BE 21.0 SECONDS
' chosen cycle length 40.0
'gested timing phase 1 is 0.5 secs green, 4.0 secs yellow + red clear
'gested timing phase 2 is 21.0 secs green, 4.0 secs yellow + red clear
'gested timing phase 3 is 1.0 secs green, 4.0 secs yellow + red clear
'gested timing phase 4 is 5.5 secs green, 4.0 secs yellow + red clear

CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 1 OF 2)
DATE:09-10-1991 TIME:18:47:09
ROGERS/RESEARCH/STADIUM NO BUILD 1992
GENERAL CHARACTERISTICS
CONTROLS: STOP
PREVAILING SPEED: 30 MPH
MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES
APPROACH: C: LOWELL RESEARC
EXCLUSIVE LEFT TURN LANES: N
EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: STADIUM PLAZA
EXCLUSIVE LEFT TURN LANES: N
EXCLUSIVE RIGHT TURN LANES: N

APPROACH	A: ROGERS NB			B: ROGERS SB			C: LOWELL RESE			D: STADIUM PLA		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	20	1055	100	0	856	10	24	5	89	110	2	75
PERCENT GRADE	0.00			0.00			0.00					
PASS CAR/HR	22			0			26	6	98	121	2	83

STEP 1 RIGHT TURNS FROM	C:LOWELL RESEARC	D:STADIUM PLAZA
CONFLICTING FLOWS	1105	861
CRITICAL GAPS	6.0	6.0
CAPACITY	252	344
DEMAND	98	83
CAPACITY USED	39	24
IMPEDANCE FACTOR	0.69	0.82
SHARED LANE	Y	Y

STEP 2 LEFT TURNS FROM	B:ROGERS SB	A:ROGERS NB
CONFLICTING FLOWS	1155	866
CRITICAL GAPS	5.0	5.0
CAPACITY	363	492
DEMAND	0	22
CAPACITY USED	0	4
IMPEDANCE FACTOR	1.00	0.98
AVAILABLE RESERVE	363	470
DELAY	Short traffic delay	Little or no delay
LOS	B	A

CULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES (PAGE 2 OF 2)
E:09-10-1991 TIME:18:47:17
ERS/RESEARCH/STADIUM NO BUILD 1992

P 3 THRU MOVES FROM	C:LOWELL RESEARC	D:STADIUM PLAZA
FLICTING FLOWS	1991	2036
TICAL GAPS	7.0	7.0
ACITY	46	43
UST FOR IMP	45	42
AND	6	2
ACITY USED	12	5
EDANCE FACTOR	0.92	0.97
RED LANE LEFT	Y	Y
RED LANE RIGHT	Y	Y

P 4 LEFT TURNS FROM	C:LOWELL RESEARC	D:STADIUM PLAZA
FLICTING FLOWS	2068	2130
TICAL GAPS	7.5	7.5
ACITY	31	28
UST FOR IMP	24	17
RED LANE THRU	Y	Y
RED LANE RIGHT	Y	Y
RED LN DEMAND	130	206
ACITY OF SHARED LN	81	28
ILABLE RESERVE	-49	-177
AY	Failure	Failure
	E*	E*

SUMMARY OF LEVEL OF SERVICE BY MOVEMENT

EMENT	DEMAND	CAPACITY	RESERVE	LOS		
FROM A:	22	492	470	A		
MOVES FROM C:	130	81	-49	E*	24	21000
MOVES FROM D:	206	28	-177	E*	200	49440

CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES
DATE:09-10-1991 TIME:18:42:31
ROGERS/CLARK NO BUILD 1999 PM PEAK

GENERAL CHARACTERISTICS
CONTROLS: STOP
PREVAILING SPEED: 30 MPH
MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES
APPROACH: C: CLARK WB
SHARED LEFT AND RIGHT TURN LANES: Y

APPROACH	A: ROGERS NB			B: ROGERS SB			C: CLARK WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	1054	504	162	975	0	441	0	166
PERCENT GRADE	0.00			0.00			0.00		
PASS CAR/HR	0			178			485	0	183

STEP 1 RIGHT TURNS FROM	C:CLARK WB
CONFLICTING FLOWS	1306
CRITICAL GAPS	6.0
CAPACITY	196
SHARED LANE	Y

STEP 2 LEFT TURNS FROM	B:ROGERS SB
CONFLICTING FLOWS	1558
CRITICAL GAPS	5.0
CAPACITY	237
DEMAND	178
CAPACITY USED	75
IMPEDANCE FACTOR	0.31
AVAILABLE RESERVE	59
DELAY	Very long delay
LOS	E

STEP 3 LEFT TURNS FROM	C:CLARK WB
CONFLICTING FLOWS	2443
CRITICAL GAPS	7.5
CAPACITY	17
ADJUST FOR IMP	5
SHARED LANE RIGHT	Y
SHARED LN DEMAND	668
CAPACITY OF SHARED LN	7
AVAILABLE RESERVE	-661
DELAY	Failure
LOS	E*

SUMMARY OF LEVEL OF SERVICE BY MOVEMENT

MOVEMENT	DEMAND	CAPACITY	RESERVE	LOS
LT FROM B:	178	237	59	E
ALL MOVES FROM C:	668	7	-661	E*

35 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
GERS/CLARK ROAD
ILD CONDITIONS 1999 PM PEAK
te:09-11-1991 time:08:34:11
ST DATA SET NAMES LOADED OR SAVED
LUME= GEOMETRICS=CLRKGEO SIGNAL=CLRKSIG
CATED IN CBD:Y

LUME & GEOMETRICS

VOLUMES			# OF LANES			LANE WIDTH			CROSS
LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
0	0	0	0	0	0	0.0	0.0	0.0	0
441	0	166	1	0	1	12.0	0.0	12.0	0
0	1054	504	0	2	1	0.0	12.0	12.0	0
162	975	0	1	2	0	12.0	12.0	0.0	0

AFFIC & ROADWAY CONDITIONS

GRADE	%HV	ADJ PARK Y/N	MOVES	BUSES	PHF	PEDESTRIANS CROSS	BUT	MIN TIME	ARR TYPE
0.0%	0.0%	N	0	0	.000	0	N	7.0	0
0.0%	1.0%	N	0	0	.900	0	N	7.0	3
0.0%	1.0%	N	0	0	.900	0	N	7.0	3
0.0%	1.0%	N	0	0	.900	0	N	7.0	3

ASINGS

EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
									*	*		*	*			40.0	4	A
												*	*			6.0	4	A
				*		*				*						25.0	4	A

CLE= 83.0

LUME ADJUSTMENT WORKSHEET
RT 1 (MOVEMENT ADJUSTMENTS)

LTV	THV	RTV	PHF	LTFR	THFR	RTFR
0	0	0	.000	0	0	0
441	0	166	.900	490	0	184
0	1054	504	.900	0	1171	560
162	975	0	.900	180	1083	0

RT 2 (LANE GROUP ADJUSTMENTS)

LN GROUP	FLOW	N	LU	v	Plt	Prt
LT	490	1	1.00	490	1.00	0.00
RT	184	1	1.00	184	0.00	1.00
TH	1171	2	1.05	1230	0.00	0.00
RT	560	1	1.00	560	0.00	1.00
LT	180	1	1.00	180	1.00	0.00
TH	1083	2	1.05	1138	0.00	0.00

T 3 (OPPOSING VOLUME ADJUSTMENTS)

T TURN NG OPPOSED	OPPOSING APPROACH VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING VOLUME
	LT	TH	RT	LT	TH	RT	LT	TH	RT	
TBOUND	0	0	0	0	0	0	0	0	0	0
THBOUND	0	1171	560	100	100	0	0	2	1	1171

URATION FLOW ADJUSTMENT WORKSHEET

LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
TH	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224
RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
TH	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
WB	LT	490	1531	0.32	0.30	461	1.06	*
WB	RT	184	1370	0.13	0.30	413	0.45	
NB	TH	1230	3224	0.38	0.48	1554	0.79	*
NB	RT	560	1370	0.41	0.83	1139	0.49	
SB	LT	180	1531	0.07	0.12	310	0.58	*
SB	TH	1138	3224	0.35	0.60	1942	0.59	

CYCLE= 83.0 LOST=12.0 SUM V/S CRIT= 0.77 TOTAL V/C= 0.90
FOR THE SOUTHBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AND V/C RATIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR 78 LEFT TURNS ON THE CHANGE INTERVAL AND 48 ON THE PERMISSIVE PHASE

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
WB	LT	1.06	0.30	83.0	22.65	461	51.58	1.00	74.22	F	14.1	
WB	RT	0.45	0.30	83.0	17.80	413	0.53	0.85	15.58	C	3.0	
NB	TH	0.79	0.48	83.0	13.69	1554	2.03	0.85	13.36	B	14.0	
NB	RT	0.49	0.83	83.0	1.52	1139	0.28	0.85	1.53	A	2.2	
SB	LT	0.58	0.60	83.0	7.67	310	2.01	1.00	9.68	B	3.7	
SB	TH	0.59	0.60	83.0	7.70	1942	0.34	0.85	6.84	B	9.9	

DIR	Delay	LOS
WB	58.19	E
NB	9.65	B
SB	7.23	B

INTERSECTION DELAY = 17.47 INTERSECTION LOS=C

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 82.5 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 63.8 SECONDS
for chosen cycle length 65.0
suggested timing phase 1 is 26.2 secs green, 4.0 secs yellow + red clear
suggested timing phase 2 is 0.8 secs green, 4.0 secs yellow + red clear
suggested timing phase 3 is 22.0 secs green, 4.0 secs yellow + red clear

:5 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
:ERS/CLARK ROAD
:LD CONDITIONS 1996 PM PEAK
:e:09-11-1991 time:08:29:52
:T DATA SET NAMES LOADED OR SAVED
:UME= GEOMETRICS=CLRKGEO SIGNAL=CLRKSIG
:ATED IN CBD:Y
:UME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
	0	0	0	0	0	0	0.0	0.0	0.0	0
	410	0	154	1	0	1	12.0	0.0	12.0	0
	0	979	468	0	2	1	0.0	12.0	12.0	0
	150	905	0	1	2	0	12.0	12.0	0.0	0

:FFIC & ROADWAY CONDITIONS

		ADJ	PARK			PEDESTRIANS			ARR
GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
0.0%	0.0%	N	0	0	.000	0	N	7.0	0
0.0%	1.0%	N	0	0	.900	0	N	7.0	3
0.0%	1.0%	N	0	0	.900	0	N	7.0	3
0.0%	1.0%	N	0	0	.900	0	N	7.0	3

:SINGS

EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
									*	*		*	*			40.0	4	A
												*	*			6.0	4	A
				*		*				*						25.0	4	A

:LE= 83.0

:UME ADJUSTMENT WORKSHEET
:T 1 (MOVEMENT ADJUSTMENTS)

LTV	THV	RTV	PHF	LTFR	THFR	RTFR
0	0	0	.000	0	0	0
410	0	154	.900	456	0	171
0	979	468	.900	0	1088	520
150	905	0	.900	167	1006	0

:T 2 (LANE GROUP ADJUSTMENTS)

LN GROUP	FLOW	N	LU	v	Plt	Prt
LT	456	1	1.00	456	1.00	0.00
RT	171	1	1.00	171	0.00	1.00
TH	1088	2	1.05	1142	0.00	0.00
RT	520	1	1.00	520	0.00	1.00
LT	167	1	1.00	167	1.00	0.00
TH	1006	2	1.05	1056	0.00	0.00

:T 3 (OPPOSING VOLUME ADJUSTMENTS)

:T TURN	OPPOSING APPROACH									
:NG OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
:TBOUND	0	0	0	0	0	0	0	0	0	0
:THBOUND	0	1088	520	100	100	0	0	2	1	1088

:URATION FLOW ADJUSTMENT WORKSHEET

LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
TH	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224
RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
TH	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
WB	LT	456	1531	0.30	0.30	461	0.99	*
WB	RT	171	1370	0.12	0.30	413	0.41	
NB	TH	1142	3224	0.35	0.48	1554	0.74	*
NB	RT	520	1370	0.38	0.83	1139	0.46	
SB	LT	167	1531	0.06	0.12	334	0.50	*
SB	TH	1056	3224	0.33	0.60	1942	0.54	

CYCLE= 83.0 LOST=12.0 SUM V/S CRIT= 0.71 TOTAL V/C= 0.83
FOR THE SOUTHBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AND V/C RATIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR 78 LEFT TURNS ON THE CHANGE INTERVAL AND 72 ON THE PERMISSIVE PHASE

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
WB	LT	0.99	0.30	83.0	21.92	461	29.22	1.00	51.15	E	10.1	
WB	RT	0.41	0.30	83.0	17.60	413	0.40	0.85	15.30	C	2.8	
NB	TH	0.74	0.48	83.0	13.11	1554	1.30	0.85	12.25	B	13.0	
NB	RT	0.46	0.83	83.0	1.45	1139	0.21	0.85	1.41	A	2.0	
SB	LT	0.50	0.60	83.0	7.13	334	1.00	1.00	8.13	B	3.4	
SB	TH	0.54	0.60	83.0	7.41	1942	0.25	0.85	6.51	B	9.2	

DIR	Delay	LOS
WB	41.36	E
NB	8.86	B
SB	6.73	B

INTERSECTION DELAY = 13.92 INTERSECTION LOS=B

THE CYCLE LENGTH WITHIN THE BOUNDS OF 40 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 69.5 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 47.9 SECONDS
for chosen cycle length 50.0
suggested timing phase 1 is 18.9 secs green, 4.0 secs yellow + red clear
suggested timing phase 2 is 0.0 secs green, 3.2 secs yellow + red clear
suggested timing phase 3 is 15.9 secs green, 4.0 secs yellow + red clear

CULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES
E:09-10-1991 TIME:18:34:28
ERS/CLARK NO BUILD 1996 PM PEAK

ERAL CHARACTERISTICS
TROLS: STOP
VAILING SPEED: 30 MPH
N STREET # OF LANES: 2 LANES

OR STREET LANES
ROACH: C: CLARK WB
RED LEFT AND RIGHT TURN LANES: Y

ROACH	A: ROGERS NB			B: ROGERS SB			C: CLARK WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
UME	0	979	468	150	905	0	410	0	154
CENT GRADE	0.00			0.00			0.00		
S CAR/HR	0			165			451	0	169

P 1 RIGHT TURNS FROM C:CLARK WB
FLICTING FLOWS 1213
TICAL GAPS 6.0
ACITY 220
RED LANE Y

P 2 LEFT TURNS FROM B:ROGERS SB
FLICTING FLOWS 1447
TICAL GAPS 5.0
ACITY 266
AND 165
ACITY USED 62
EDANCE FACTOR 0.45
ILABLE RESERVE 101
AY Long delay
D

P 3 LEFT TURNS FROM C:CLARK WB
FLICTING FLOWS 2268
TICAL GAPS 7.5
ACITY 23
UST FOR IMP 10
RED LANE RIGHT Y
RED LN DEMAND 620
ACITY OF SHARED LN 14
ILABLE RESERVE -607
AY Failure
E*

SUMMARY OF LEVEL OF SERVICE BY MOVEMENT

EMENT	DEMAND	CAPACITY	RESERVE	LOS
FROM B:	165	266	101	D
MOVES FROM C:	620	14	-607	E*

CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES
DATE:09-10-1991 TIME:18:32:28
ROGERS/CLARK NO BUILD 1995 PM PEAK

GENERAL CHARACTERISTICS
CONTROLS: STOP
PREVAILING SPEED: 30 MPH
MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES
APPROACH: C: CLARK WB
SHARED LEFT AND RIGHT TURN LANES: Y

APPROACH	A: ROGERS NB			B: ROGERS SB			C: CLARK WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	955	457	147	883	0	400	0	150
PERCENT GRADE	0.00			0.00			0.00		
PASS CAR/HR	0			162			440	0	165

STEP 1 RIGHT TURNS FROM	C:CLARK WB
CONFLICTING FLOWS	1184
CRITICAL GAPS	6.0
CAPACITY	228
SHARED LANE	Y

STEP 2 LEFT TURNS FROM	B:ROGERS SB
CONFLICTING FLOWS	1412
CRITICAL GAPS	5.0
CAPACITY	276
DEMAND	162
CAPACITY USED	58
IMPEDANCE FACTOR	0.49
AVAILABLE RESERVE	115
DELAY	Long delay
LOS	D

STEP 3 LEFT TURNS FROM	C:CLARK WB
CONFLICTING FLOWS	2214
CRITICAL GAPS	7.5
CAPACITY	25
ADJUST FOR IMP	12
SHARED LANE RIGHT	Y
SHARED LN DEMAND	605
CAPACITY OF SHARED LN	16
AVAILABLE RESERVE	-589
DELAY	Failure
LOS	E*

SUMMARY OF LEVEL OF SERVICE BY MOVEMENT

MOVEMENT	DEMAND	CAPACITY	RESERVE	LOS
LT FROM B:	162	276	115	D
ALL MOVES FROM C:	605	16	-589	E*

5 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ERS/CLARK ROAD
LD CONDITIONS 1995 PM PEAK
e:09-11-1991 time:08:25:33
T DATA SET NAMES LOADED OR SAVED
UME= GEOMETRICS=CLRKGEO SIGNAL=CLRKSIG
ATED IN CBD:Y
UME & GEOMETRICS

VOLUMES			# OF LANES			LANE WIDTH			CROSS
LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
0	0	0	0	0	0	0.0	0.0	0.0	0
400	0	150	1	0	1	12.0	0.0	12.0	0
0	955	457	0	2	1	0.0	12.0	12.0	0
147	883	0	1	2	0	12.0	12.0	0.0	0

FFIC & ROADWAY CONDITIONS

GRADE	%HV	ADJ PARK Y/N	MOVES	BUSES	PHF	PEDESTRIANS CROSS	BUT	MIN TIME	ARR TYPE
0.0%	0.0%	N	0	0	.000	0	N	7.0	0
0.0%	1.0%	N	0	0	.900	0	N	7.0	3
0.0%	1.0%	N	0	0	.900	0	N	7.0	3
0.0%	1.0%	N	0	0	.900	0	N	7.0	3

SINGS

EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
									*	*		*	*			30.0	4	A
												*	*			6.0	4	A
				*		*				*						20.0	4	A

LE= 68.0

UME ADJUSTMENT WORKSHEET
T 1 (MOVEMENT ADJUSTMENTS)

LTV	THV	RTV	PHF	LTFR	THFR	RTFR
0	0	0	.000	0	0	0
400	0	150	.900	444	0	167
0	955	457	.900	0	1061	508
147	883	0	.900	163	981	0

T 2 (LANE GROUP ADJUSTMENTS)

LN GROUP	FLOW	N	LU	v	Plt	Prt
LT	444	1	1.00	444	1.00	0.00
RT	167	1	1.00	167	0.00	1.00
TH	1061	2	1.05	1114	0.00	0.00
RT	508	1	1.00	508	0.00	1.00
LT	163	1	1.00	163	1.00	0.00
TH	981	2	1.05	1030	0.00	0.00

T 3 (OPPOSING VOLUME ADJUSTMENTS)

T TURN	OPPOSING APPROACH									
NG OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
TBOUND	0	0	0	0	0	0	0	0	0	0
THBOUND	0	1061	508	100	100	0	0	2	1	1061

URATION FLOW ADJUSTMENT WORKSHEET

LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
TH	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224
RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
TH	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224

PACIT
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'ACITY ANALYSIS WORKSHEET

LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
LT	444	1531	0.29	0.29	450	0.99	*
RT	167	1370	0.12	0.29	403	0.41	
TH	1114	3224	0.35	0.44	1422	0.78	*
RT	508	1370	0.37	0.79	1088	0.47	
LT	163	1531	0.06	0.15	383	0.43	*
TH	1030	3224	0.32	0.59	1896	0.54	

LE= 68.0 LOST=12.0 SUM V/S CRIT= 0.70 TOTAL V/C= 0.85
THE SOUTHBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AND V/C
TIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR
LEFT TURNS ON THE CHANGE INTERVAL AND 63 ON THE PERMISSIVE PHASE

'EL OF SERVICE WORKSHEET

LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
LT	0.99	0.29	68.0	18.14	450	29.39	1.00	47.53	E	8.8	
RT	0.41	0.29	68.0	14.66	403	0.41	0.85	12.81	B	2.2	
TH	0.78	0.44	68.0	12.33	1422	2.07	0.85	12.24	B	11.2	
RT	0.47	0.79	68.0	1.74	1088	0.24	0.85	1.68	A	2.0	
LT	0.43	0.59	68.0	5.85	383	0.48	1.00	6.33	B	2.6	
TH	0.54	0.59	68.0	6.44	1896	0.25	0.85	5.69	B	7.6	

Delay	LOS
38.06	D
8.93	B
5.78	B

'ERSECTION DELAY = 13.03 INTERSECTION LOS=B

CYCLE LENGTH WITHIN THE BOUNDS OF 30 TO 120 SECONDS
CH MINIMIZES CRITICAL MOVEMENT DELAY IS 67.0 SECONDS

A V/C RATIO OF .95 THE CYCLE SHOULD BE 45.3 SECONDS
chosen cycle length 70.0
gested timing phase 1 is 28.7 secs green, 4.0 secs yellow + red clear
gested timing phase 2 is 1.2 secs green, 4.0 secs yellow + red clear
gested timing phase 3 is 24.1 secs green, 4.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ROGERS/CLARK ROAD
BUILD YEAR 1992 PM PEAK
date:09-11-1991 time:08:21:20
LAST DATA SET NAMES LOADED OR SAVED
VOLUME= GEOMETRICS=CLRKGEO SIGNAL=CLRKSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	0	0	0	0	0	0	0.0	0.0	0.0	0
WB	371	0	139	1	0	1	12.0	0.0	12.0	0
NB	0	887	424	0	2	1	0.0	12.0	12.0	0
SB	136	820	0	1	2	0	12.0	12.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	0.0%	N	0	0	.000	0	N	7.0	0
WB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
NB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3
SB	0.0%	1.0%	N	0	0	.900	0	N	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1										*	*		*	*			40.0	4	A
2													*	*			6.0	4	A
3					*		*				*						25.0	4	A

CYCLE= 83.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	0	0	.000	0	0	0
WB	371	0	139	.900	412	0	154
NB	0	887	424	.900	0	986	471
SB	136	820	0	.900	151	911	0

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
WB	LT	412	1	1.00	412	1.00	0.00
WB	RT	154	1	1.00	154	0.00	1.00
NB	TH	986	2	1.05	1035	0.00	0.00
NB	RT	471	1	1.00	471	0.00	1.00
SB	LT	151	1	1.00	151	1.00	0.00
SB	TH	911	2	1.05	957	0.00	0.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
WESTBOUND	0	0	0	0	0	0	0	0	0	0
SOUTHBOUND	0	986	471	100	100	0	0	2	1	986

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
WB	LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
WB	RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
NB	TH	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224
NB	RT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	0.850	1.000	1370
SB	LT	1800	1	1.000	0.995	1.000	1.000	1.000	0.900	1.000	0.950	1531
SB	TH	1800	2	1.000	0.995	1.000	1.000	1.000	0.900	1.000	1.000	3224

PACITY ANALYSIS WORKSHEET

R LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
LT	412	1531	0.27	0.30	461	0.89	*
RT	154	1370	0.11	0.30	413	0.37	
TH	1035	3224	0.32	0.48	1554	0.67	*
RT	471	1370	0.34	0.83	1139	0.41	
LT	151	1531	0.05	0.12	369	0.41	*
TH	957	3224	0.30	0.60	1942	0.49	

CLE= 83.0 LOST=12.0 SUM V/S CRIT= 0.64 TOTAL V/C= 0.75
R THE SOUTHBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AND V/C
ATIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR
8 LEFT TURNS ON THE CHANGE INTERVAL AND 106 ON THE PERMISSIVE PHASE

VEL OF SERVICE WORKSHEET

R LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
LT	0.89	0.30	83.0	21.07	461	13.73	1.00	34.81	D	7.3	
RT	0.37	0.30	83.0	17.36	413	0.28	0.85	14.99	B	2.5	
TH	0.67	0.48	83.0	12.47	1554	0.78	0.85	11.26	B	11.8	
RT	0.41	0.83	83.0	1.37	1139	0.15	0.85	1.29	A	1.8	
LT	0.41	0.60	83.0	6.62	369	0.43	1.00	7.05	B	3.1	
TH	0.49	0.60	83.0	7.09	1942	0.17	0.85	6.17	B	8.4	

R Delay	LOS
29.41	D
8.14	B
6.29	B

TERSECTION DELAY = 11.28 INTERSECTION LOS=B

E CYCLE LENGTH WITHIN THE BOUNDS OF 30 TO 120 SECONDS
ICH MINIMIZES CRITICAL MOVEMENT DELAY IS 57.6 SECONDS

R A V/C RATIO OF .95 THE CYCLE SHOULD BE 36.7 SECONDS
r chosen cycle length 60.0
ggested timing phase 1 is 24.1 secs green, 4.0 secs yellow + red clear
ggested timing phase 2 is 0.0 secs green, 3.7 secs yellow + red clear
ggested timing phase 3 is 20.2 secs green, 4.0 secs yellow + red clear

CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES
DATE:09-10-1991 TIME:18:30:33
ROGERS/CLARK NO BUILD 1991 PM PEAK

GENERAL CHARACTERISTICS
CONTROLS: STOP
PREVAILING SPEED: 30 MPH
MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES
APPROACH: C: CLARK WB
SHARED LEFT AND RIGHT TURN LANES: Y

APPROACH	A: ROGERS NB			B: ROGERS SB			C: CLARK WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	865	414	133	800	0	362	0	136
PERCENT GRADE	0.00			0.00			0.00		
PASS CAR/HR	0			146			398	0	150

STEP 1 RIGHT TURNS FROM	C:CLARK WB
CONFLICTING FLOWS	1072
CRITICAL GAPS	6.0
CAPACITY	263
SHARED LANE	Y

STEP 2 LEFT TURNS FROM	B:ROGERS SB
CONFLICTING FLOWS	1279
CRITICAL GAPS	5.0
CAPACITY	318
DEMAND	146
CAPACITY USED	46
IMPEDANCE FACTOR	0.62
AVAILABLE RESERVE	172
DELAY	Long delay
LOS	D

STEP 3 LEFT TURNS FROM	C:CLARK WB
CONFLICTING FLOWS	2005
CRITICAL GAPS	7.5
CAPACITY	34
ADJUST FOR IMP	21
SHARED LANE RIGHT	Y
SHARED LN DEMAND	548
CAPACITY OF SHARED LN	28
AVAILABLE RESERVE	-520
DELAY	Failure
LOS	E*

SUMMARY OF LEVEL OF SERVICE BY MOVEMENT

MOVEMENT	DEMAND	CAPACITY	RESERVE	LOS
LT FROM B:	146	318	172	D
ALL MOVES FROM C:	548	28	-520	E*

AIR QUALITY ANALYSIS FOR MONUMENT SQUARE PROJECT LOWELL, MASSACHUSETTS

MONMNTSQ.WK1

MONUMENT SQUARE IMPROVEMENTS
LOWELL, MA

AIR QUALITY ANALYSIS

EMISSIONS (KG/DAY)

==========
EXISTING CONDITIONS
DELAY (HOURS/DAY)

BUILD	258.37
NO-BUILD	1144.95
NET	-886.58

==========

ANALYSIS YEAR		NMHC	CO
1992			
	BUILD	6.09	113.48
	NO-BUILD	27	502.63
	NET	-20.91	-389.15
1995			
	BUILD	N/A	100.44
	NO-BUILD	N/A	563.68
	NET	N/A	-463.24
1996			
	BUILD	6.6	N/A
	NO-BUILD	39.58	N/A
	NET	-32.98	N/A
1999			
	BUILD	8.23	N/A
	NO-BUILD	57.06	N/A
	NET	-48.83	N/A

AIRCALC.WPG

MERRIMACK/WORTHEN/ARCAND
INTERSECTION

YEAR 1992	DELAY/SEC	DELAY/HR	CO
BUILD	3,025	8.40	3.69
NO-BUILD	70,936	196.99	86.52
NET	(67,911)	-188.59	(82.83)

YEAR 1992	DELAY/SEC	DELAY/HR	NMHC
BUILD	3,025	8.40	0.20
NO-BUILD	70,936	196.99	4.65
NET	(67,911)	-188.59	(4.45)

YEAR 1995	DELAY/SEC	DELAY/HR	CO
BUILD	3,356	9.32	2.92
NO-BUILD	101,152	280.90	87.87
NET	(97,796)	-271.58	(84.96)

YEAR 1996	DELAY/SEC	DELAY/HR	NMHC
BUILD	3,489	9.69	0.18
NO-BUILD	114,998	319.35	6.03
NET	(111,509)	-309.66	(5.84)

YEAR 1999	DELAY/SEC	DELAY/HR	NMHC
BUILD	3,849	10.69	0.19
NO-BUILD	170,522	473.54	8.23
NET	(166,673)	-462.85	(8.04)

AIRCALC.WPG

MERRIMACK/DUTTON/ARCAND
INTERSECTION

YEAR 1992	DELAY/SEC	DELAY/HR	CO
BUILD	34,822	96.70	42.47
NO-BUILD	168,923	469.10	206.04
NET	(134,102)	-372.40	(163.57)

YEAR 1992	DELAY/SEC	DELAY/HR	NMHC
BUILD	34,822	96.70	2.28
NO-BUILD	168,923	469.10	11.07
NET	(134,102)	-372.40	(8.79)

YEAR 1995	DELAY/SEC	DELAY/HR	CO
BUILD	41,088	114.10	33.69
NO-BUILD	257,407	714.82	221.62
NET	(216,320)	-600.72	(187.92)

YEAR 1996	DELAY/SEC	DELAY/HR	NMHC
BUILD	43,846	121.76	2.30
NO-BUILD	296,003	822.00	15.51
NET	(252,157)	-700.24	(13.21)

YEAR 1999	DELAY/SEC	DELAY/HR	NMHC
BUILD	55,275	153.50	2.67
NO-BUILD	442,204	1228.00	21.33
NET	(386,928)	-1074.50	(18.66)

AIRCALC.WPG

ARCAND ST. & FRENCH ST
INTERSECTION

YEAR 1992	DELAY/SEC	DELAY/HR	CO
BUILD	55,191	153.27	67.32
NO-BUILD	172,222	478.26	210.07
NET	(117,031)	-324.99	(142.75)

YEAR 1992	DELAY/SEC	DELAY/HR	NMHC
BUILD	55,191	153.27	3.62
NO-BUILD	172,222	478.26	11.29
NET	(117,031)	-325.00	(7.67)

YEAR 1995	DELAY/SEC	DELAY/HR	CO
BUILD	71,168	197.63	61.83
NO-BUILD	290,293	806.14	252.19
NET	(219,125)	-608.51	(190.36)

YEAR 1996	DELAY/SEC	DELAY/HR	NMHC
BUILD	78,648	218.41	4.12
NO-BUILD	344,516	956.72	18.05
NET	(265,868)	-738.32	(13.93)

YEAR 1999	DELAY/SEC	DELAY/HR	NMHC
BUILD	111,455	309.51	5.38
NO-BUILD	570,812	1585.15	27.53
NET	(459,357)	-1275.64	(22.16)

35 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
RRIMACK/DUTTON/ARCAND
92 NO-BUILD CONDITIONS
te:10-28-1992 time:09:51:47
ST DATA SET NAMES LOADED OR SAVED
LUME=DUTTONV GEOMETRICS=AIKENA SIGNAL=DUTTONS
CATED IN CBD:Y

LUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
R	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
	39	426	0	0	2	0	0.0	12.0	0.0	48
	0	0	0	0	0	0	0.0	0.0	0.0	24
	443	312	130	0	2	0	0.0	12.0	0.0	30
	27	0	503	0	1	1	0.0	12.0	12.0	30

AFFIC & ROADWAY CONDITIONS

			ADJ PARK			PEDESTRIANS			ARR
R	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
	0.0%	4.0%	N	0	0	.900	5	Y	19.0	3
	0.0%	0.0%	N	0	0	.900	5	Y	19.0	3
	0.0%	4.0%	N	0	0	.900	5	Y	14.5	3
	0.0%	4.0%	N	0	0	.900	5	Y	14.5	3

ASINGS

EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y-R	PRE/ACT
l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
*	*										*			*		36.0	30	P
								*	*	*		*		*		36.0	30	P

CLE= 132.0

LUME ADJUSTMENT WORKSHEET
RT 1 (MOVEMENT ADJUSTMENTS)

R	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
	39	426	0	.900	43	473	0
	0	0	0	.900	42	237	60
	443	312	130	.900	492	347	144
	27	0	503	.900	30	0	559

RT 2 (LANE GROUP ADJUSTMENTS)

R	LN GROUP	FLOW	N	LU	v	Plt	Prt
	LT-TH	517	2	1.05	543	0.08	0.00
	LT-TH-RT	983	2	1.05	1033	0.50	0.15
	LT-TH	30	1	1.00	30	1.00	0.00
	RT	559	1	1.00	559	0.00	1.00

RT 3 (OPPOSING VOLUME ADJUSTMENTS)

FT TURN	OPPOSING APPROACH									
ING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
STBOUND	42	237	60	0	0	0	0	0	0	0
RTHBOUND	30	0	559	100	0	0	0	1	1	0
UTHBOUND	492	347	144	100	100	100	0	2	0	983

TURATION FLOW ADJUSTMENT WORKSHEET

R	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
	LT-TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
	LT-TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.111	176
	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350

PPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT
PUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
SB	132	36	1	30	559	30	1.00	2	983	0.50

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
SB	2292	0.429	0.000	0.260	1.000	36.000	0.000	0.000	4.320	0.111	0.111

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT-TH	543	3176	0.17	0.27	866	0.63	*
NB	LT-TH-RT	1033	3176	0.33	0.27	866	1.19	
SB	LT-TH	30	176	0.17	0.00	0	0.00	
SB	RT	559	1350	0.41	1.00	1350	0.41	

CYCLE=132.0 LOST=60.0 SUM V/S CRIT= 0.17 TOTAL V/C= 0.31

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT-TH	0.63	0.27	132.0	32.00	866	1.03	1.00	33.02	D	13.8	
NB	LT-TH-RT	1.19	0.27	132.0	39.31	866	106.74	1.00	146.05	F	53.0	
SB	LT-TH	0.00	0.00	132.0	0.00	0	0.00	1.00	0.00	A	1.1	
SB	RT	0.41	1.00	132.0	0.00	1350	0.12	1.00	0.12	A	0.0	

DIR	Delay	LOS
EB	33.02	D
NB	146.05	F
SB	0.12	A

INTERSECTION DELAY = 78.00 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 70 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 73.2 SECONDS
for chosen cycle length 65.0
suggested timing phase 1 is 11.1 secs green, 30.0 secs yellow + red clear
suggested timing phase 2 is 0.0 secs green, 30.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERRIMACK/DUTTON/ARCAND
1995 NO-BUILD CONDITIONS
date:10-28-1992 time:09:48:26
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=DUTTONV GEOMETRICS=AIKENA SIGNAL=DUTTONS
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	42	459	0	0	2	0	0.0	12.0	0.0	48
WB	0	0	0	0	0	0	0.0	0.0	0.0	24
NB	477	336	140	0	2	0	0.0	12.0	0.0	30
SB	29	0	542	0	1	1	0.0	12.0	12.0	30

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	19.0	3
WB	0.0%	0.0%	N	0	0	.900	5	Y	19.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	14.5	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	14.5	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y-R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*										*			*		36.0	30	P
2									*	*	*		*		*		36.0	30	P

CYCLE= 132.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	42	459	0	.900	47	510	0
WB	0	0	0	.900	42	237	60
NB	477	336	140	.900	530	373	156
SB	29	0	542	.900	32	0	602

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT-TH	557	2	1.05	585	0.08	0.00
NB	LT-TH-RT	1059	2	1.05	1112	0.50	0.15
SB	LT-TH	32	1	1.00	32	1.00	0.00
SB	RT	602	1	1.00	602	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	42	237	60	0	0	0	0	0	0	0
NORTHBOUND	32	0	602	100	0	0	0	1	1	0
SOUTHBOUND	530	373	156	100	100	100	0	2	0	1059

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT-TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
SB	LT-TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.111	176
SB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
SB	132	36	1	32	602	32	1.00	2	1059	0.50

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
SB	2210	0.479	0.000	0.213	1.000	36.000	0.000	0.000	5.277	0.111	0.111

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT-TH	585	3176	0.18	0.27	866	0.67	*
NB	LT-TH-RT	1112	3176	0.35	0.27	866	1.28	
SB	LT-TH	32	176	0.18	0.00	0	0.00	
SB	RT	602	1350	0.45	1.00	1350	0.45	

CYCLE=132.0 LOST=60.0 SUM V/S CRIT= 0.18 TOTAL V/C= 0.34

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT-TH	0.67	0.27	132.0	32.51	866	1.47	1.00	33.98	D	14.8	
NB	LT-TH-RT	1.28	0.27	132.0	40.82	866	172.67	1.00	213.49	F	76.9	
SB	LT-TH	0.00	0.00	132.0	0.00	0	0.00	1.00	0.00	A	1.2	
SB	RT	0.45	1.00	132.0	0.00	1350	0.16	1.00	0.16	A	0.0	

DIR	Delay	LOS
EB	33.98	D
NB	213.49	F
SB	0.16	A

INTERSECTION DELAY =110.40 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 75 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 74.4 SECONDS
for chosen cycle length 65.0
suggested timing phase 1 is 12.0 secs green, 30.0 secs yellow + red clear
suggested timing phase 2 is 0.0 secs green, 30.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERRIMACK/DUTTON/ARCAND
1996 NO-BUILD CONDITIONS
date:10-28-1992 time:09:44:10
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=DUTTONV GEOMETRICS=AIKENA SIGNAL=DUTTONS
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	43	471	0	0	2	0	0.0	12.0	0.0	48
WB	0	0	0	0	0	0	0.0	0.0	0.0	24
NB	489	344	144	0	2	0	0.0	12.0	0.0	30
SB	29	0	556	0	1	1	0.0	12.0	12.0	30

TRAFFIC & ROADWAY CONDITIONS

			ADJ	PARK			PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	19.0	3
WB	0.0%	0.0%	N	0	0	.900	5	Y	19.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	14.5	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	14.5	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y-R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*										*			*		36.0	30	P
2									*	*	*		*		*		36.0	30	P

CYCLE= 132.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	43	471	0	.900	48	523	0
WB	0	0	0	.900	42	237	60
NB	489	344	144	.900	543	382	160
SB	29	0	556	.900	32	0	618

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT-TH	571	2	1.05	600	0.08	0.00
NB	LT-TH-RT	1086	2	1.05	1140	0.50	0.15
SB	LT-TH	32	1	1.00	32	1.00	0.00
SB	RT	618	1	1.00	618	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	42	237	60	0	0	0	0	0	0	0
NORTHBOUND	32	0	618	100	0	0	0	1	1	0
SOUTHBOUND	543	382	160	100	100	100	0	2	0	1086

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT-TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
SB	LT-TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.111	176
SB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
SB	132	36	1	32	618	32	1.00	2	1086	0.50

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
SB	2180	0.498	0.000	0.197	1.000	36.000	0.000	0.000	5.724	0.111	0.111

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT-TH	600	3176	0.19	0.27	866	0.69	*
NB	LT-TH-RT	1140	3176	0.36	0.27	866	1.32	
SB	LT-TH	32	176	0.18	0.00	0	0.00	
SB	RT	618	1350	0.46	1.00	1350	0.46	

CYCLE=132.0 LOST=60.0 SUM V/S CRIT= 0.19 TOTAL V/C= 0.35

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT-TH	0.69	0.27	132.0	32.71	866	1.67	1.00	34.37	D	15.2	
NB	LT-TH-RT	1.32	0.27	132.0	41.38	866	200.02	1.00	241.39	F	87.3	
SB	LT-TH	0.00	0.00	132.0	0.00	0	0.00	1.00	0.00	A	1.2	
SB	RT	0.46	1.00	132.0	0.00	1350	0.18	1.00	0.18	A	0.0	

DIR	Delay	LOS
EB	34.37	D
NB	241.39	F
SB	0.17	A

INTERSECTION DELAY =123.82 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 60 TO 75 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 60.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 74.9 SECONDS
for chosen cycle length 60.0
suggested timing phase 1 is 11.3 secs green, 30.0 secs yellow + red clear
suggested timing phase 2 is 0.0 secs green, 30.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERRIMACK/DUTTON/ARCAND
1999 NO-BUILD CONDITIONS
date:10-28-1992 time:09:55:15
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=DUTTONV GEOMETRICS=AIKENA SIGNAL=DUTTONS
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	46	507	0	0	2	0	0.0	12.0	0.0	48
WB	0	0	0	0	0	0	0.0	0.0	0.0	24
NB	526	370	155	0	2	0	0.0	12.0	0.0	30
SB	32	0	598	0	1	1	0.0	12.0	12.0	30

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	19.0	3
WB	0.0%	0.0%	N	0	0	.900	5	Y	19.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	14.5	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	14.5	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*										*			*		36.0	30	P
2									*	*	*		*		*		36.0	30	P

CYCLE= 132.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	46	507	0	.900	51	563	0
WB	0	0	0	.900	42	237	60
NB	526	370	155	.900	584	411	172
SB	32	0	598	.900	36	0	664

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT-TH	614	2	1.05	645	0.08	0.00
NB	LT-TH-RT	1168	2	1.05	1226	0.50	0.15
SB	LT-TH	36	1	1.00	36	1.00	0.00
SB	RT	664	1	1.00	664	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	42	237	60	0	0	0	0	0	0	0
NORTHBOUND	36	0	664	100	0	0	0	1	1	0
SOUTHBOUND	584	411	172	100	100	100	0	2	0	1168

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT-TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
SB	LT-TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.111	176
B	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
SB	132	36	1	36	664	36	1.00	2	1168	0.50

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
SB	2088	0.559	0.000	0.145	1.000	36.000	0.000	0.000	7.751	0.111	0.111

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT-TH	645	3176	0.20	0.27	866	0.74	*
NB	LT-TH-RT	1226	3176	0.39	0.27	866	1.42	
SB	LT-TH	36	176	0.20	0.00	0	0.00	
SB	RT	664	1350	0.49	1.00	1350	0.49	

CYCLE=132.0 LOST=60.0 SUM V/S CRIT= 0.20 TOTAL V/C= 0.37

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95%
EB	LT-TH	0.74	0.27	132.0	33.29	866	2.46	1.00	35.75	D	16.4	
NB	LT-TH-RT	1.42	0.27	132.0	43.21	866	298.45	1.00	341.66	F	126.4	
SB	LT-TH	0.00	0.00	132.0	0.00	0	0.00	1.00	0.00	A	1.3	
SB	RT	0.49	1.00	132.0	0.00	1350	0.24	1.00	0.24	A	0.0	

DIR	Delay	LOS
EB	35.75	D
NB	341.66	F
SB	0.23	A

INTERSECTION DELAY =171.96 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 75 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 76.3 SECONDS
for chosen cycle length 50.0
suggested timing phase 1 is 10.2 secs green, 30.0 secs yellow + red clear
suggested timing phase 2 is 0.0 secs green, 30.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERRIMACK/DUTTON/ARCAND
1992 BUILD CONDITIONS
date:10-28-1992 time:12:51:22
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=DUTTONV GEOMETRICS=DUTBGEO SIGNAL=DUTBSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	39	426	0	0	2	0	0.0	12.0	0.0	60
WB	0	319	0	0	2	0	0.0	12.0	0.0	50
NB	443	312	130	1	1	0	12.0	12.0	0.0	40
SB	0	0	185	0	0	2	0.0	0.0	12.0	40

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	22.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	22.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	14.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	14.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1								*	*	*	*						35.5	3	A
2	*	*													*	*	14.6	3	A
3	*	*					*					*				*	14.9	3	A
4				*				*				*				*	0.0	6	A

CYCLE= 80.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	39	426	0	.900	43	473	0
WB	0	319	0	.900	0	354	0
NB	443	312	130	.900	492	347	144
SB	0	0	185	.900	0	0	206

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT-TH	517	2	1.05	543	0.08	0.00
WB	TH	354	2	1.05	372	0.00	0.00
NB	LT	492	1	1.00	492	1.00	0.00
NB	TH-RT	491	1	1.00	491	0.00	0.29
SB	RT	206	2	1.05	216	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	0	354	0	100	100	0	0	2	0	354
NORTHBOUND	0	0	206	0	0	0	0	0	2	0

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.970	3080
WB	TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
NB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.860	1.000	1365
SB	RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	0.750	1.000	2382

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT-TH	543	3080	0.18	0.41	1251	0.43	
WB	TH	372	3176	0.12	0.19	592	0.63	*
NB	LT	492	1509	0.33	0.44	670	0.74	
NB	TH-RT	491	1365	0.36	0.44	606	0.81	*
SB	RT	216	2382	0.09	0.18	435	0.50	*

CYCLE= 80.0 LOST=15.0 SUM V/S CRIT= 0.57 TOTAL V/C= 0.70

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT-TH	0.43	0.41	80.0	13.01	1251	0.16	0.85	11.19	B	6.8	
WB	TH	0.63	0.19	80.0	22.80	592	1.52	0.85	20.68	C	6.4	
NB	LT	0.74	0.44	80.0	13.96	670	2.93	1.00	16.89	C	6.1	
NB	TH-RT	0.81	0.44	80.0	14.69	606	5.68	0.85	17.31	C	6.1	
SB	RT	0.50	0.18	80.0	22.34	435	0.76	0.85	19.64	C	3.7	

DIR	Delay	LOS
EB	11.19	B
WB	20.68	C
NB	17.10	C
SB	19.64	C

INTERSECTION DELAY = 16.47 INTERSECTION LOS=C

THE CYCLE LENGTH WITHIN THE BOUNDS OF 30 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 30.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 37.3 SECONDS
for chosen cycle length 80.0
suggested timing phase 1 is 28.8 secs green, 3.0 secs yellow + red clear
suggested timing phase 2 is 7.2 secs green, 3.0 secs yellow + red clear
suggested timing phase 3 is 9.4 secs green, 3.0 secs yellow + red clear
suggested timing phase 4 is 0.0 secs green, 6.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERRIMACK/DUTTON/ARCAND
1995 BUILD CONDITIONS
date:10-28-1992 time:12:57:24
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=DUTTONV GEOMETRICS=DUTBGEO SIGNAL=DUTBSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	42	459	0	0	2	0	0.0	12.0	0.0	60
WB	0	343	0	0	2	0	0.0	12.0	0.0	50
NB	477	336	140	1	1	0	12.0	12.0	0.0	40
SB	0	0	199	0	0	2	0.0	0.0	12.0	40

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	22.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	22.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	14.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	14.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y-R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1								*	*	*	*						35.5	3	A
2	*	*													*	*	14.6	3	A
3	*	*					*					*				*	14.9	3	A
4				*				*				*				*	0.0	6	A

CYCLE= 80.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	42	459	0	.900	47	510	0
WB	0	343	0	.900	0	381	0
NB	477	336	140	.900	530	373	156
SB	0	0	199	.900	0	0	221

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT-TH	557	2	1.05	585	0.08	0.00
WB	TH	381	2	1.05	400	0.00	0.00
NB	LT	530	1	1.00	530	1.00	0.00
NB	TH-RT	529	1	1.00	529	0.00	0.29
SB	RT	221	2	1.05	232	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	0	381	0	100	100	0	0	2	0	381
NORTHBOUND	0	0	221	0	0	0	0	0	2	0

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.968	3075
WB	TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
NB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.860	1.000	1365
SB	RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	0.750	1.000	2382

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT-TH	585	3075	0.19	0.41	1249	0.47	
WB	TH	400	3176	0.13	0.19	592	0.68	*
NB	LT	530	1509	0.35	0.44	670	0.79	
NB	TH-RT	529	1365	0.39	0.44	606	0.87	*
SB	RT	232	2382	0.10	0.18	435	0.53	*

CYCLE= 80.0 LOST=15.0 SUM V/S CRIT= 0.61 TOTAL V/C= 0.75

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT-TH	0.47	0.41	80.0	13.23	1249	0.21	0.85	11.43	B	7.3	
WB	TH	0.68	0.19	80.0	23.03	592	2.15	0.85	21.40	C	6.9	
NB	LT	0.79	0.44	80.0	14.50	670	4.48	1.00	18.98	C	6.6	
NB	TH-RT	0.87	0.44	80.0	15.35	606	9.36	0.85	21.00	C	6.5	
SB	RT	0.53	0.18	80.0	22.51	435	1.02	0.85	20.00	C	4.0	

DIR	Delay	LOS
EB	11.43	B
WB	21.40	C
NB	19.99	C
SB	20.00	C

INTERSECTION DELAY = 18.04 INTERSECTION LOS=C

THE CYCLE LENGTH WITHIN THE BOUNDS OF 70 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 70.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 42.0 SECONDS
for chosen cycle length 80.0
suggested timing phase 1 is 31.0 secs green, 3.0 secs yellow + red clear
suggested timing phase 2 is 7.8 secs green, 3.0 secs yellow + red clear
suggested timing phase 3 is 10.1 secs green, 3.0 secs yellow + red clear
suggested timing phase 4 is 0.0 secs green, 6.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERRIMACK/DUTTON/ARCAND
1996 BUILD CONDITIONS
date:10-28-1992 time:13:02:47
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=DUTTONV GEOMETRICS=DUTBGEO SIGNAL=DUTBSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	43	471	0	0	2	0	0.0	12.0	0.0	60
WB	0	352	0	0	2	0	0.0	12.0	0.0	50
NB	489	344	144	1	1	0	12.0	12.0	0.0	40
SB	0	0	204	0	0	2	0.0	0.0	12.0	40

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	22.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	22.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	14.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	14.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1								*	*	*	*						35.5	3	A
2	*	*													*	*	14.6	3	A
3	*	*					*					*				*	14.9	3	A
4				*				*				*				*	0.0	6	A

CYCLE= 80.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	43	471	0	.900	48	523	0
WB	0	352	0	.900	0	391	0
NB	489	344	144	.900	543	382	160
SB	0	0	204	.900	0	0	227

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT-TH	571	2	1.05	600	0.08	0.00
WB	TH	391	2	1.05	411	0.00	0.00
NB	LT	543	1	1.00	543	1.00	0.00
NB	TH-RT	542	1	1.00	542	0.00	0.30
SB	RT	227	2	1.05	238	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	0	391	0	100	100	0	0	2	0	391
NORTHBOUND	0	0	227	0	0	0	0	0	2	0

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.967	3073
WB	TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
NB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.859	1.000	1365
SB	RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	0.750	1.000	2382

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT-TH	600	3073	0.20	0.41	1248	0.48	
WB	TH	411	3176	0.13	0.19	592	0.69	*
NB	LT	543	1509	0.36	0.44	670	0.81	
NB	TH-RT	542	1365	0.40	0.44	606	0.90	*
SB	RT	238	2382	0.10	0.18	435	0.55	*

CYCLE= 80.0 LOST=15.0 SUM V/S CRIT= 0.63 TOTAL V/C= 0.77

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT-TH	0.48	0.41	80.0	13.32	1248	0.24	0.85	11.52	B	7.5	
WB	TH	0.69	0.19	80.0	23.12	592	2.44	0.85	21.73	C	7.1	
NB	LT	0.81	0.44	80.0	14.70	670	5.22	1.00	19.92	C	6.7	
NB	TH-RT	0.90	0.44	80.0	15.60	606	11.27	0.85	22.84	C	6.8	
SB	RT	0.55	0.18	80.0	22.57	435	1.13	0.85	20.14	C	4.1	

DIR	Delay	LOS
EB	11.52	B
WB	21.73	C
NB	21.38	C
SB	20.14	C

INTERSECTION DELAY = 18.78 INTERSECTION LOS=C

THE CYCLE LENGTH WITHIN THE BOUNDS OF 60 TO 100 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 60.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 44.0 SECONDS
for chosen cycle length 80.0
suggested timing phase 1 is 31.8 secs green, 3.0 secs yellow + red clear
suggested timing phase 2 is 8.0 secs green, 3.0 secs yellow + red clear
suggested timing phase 3 is 10.3 secs green, 3.0 secs yellow + red clear
suggested timing phase 4 is 0.0 secs green, 6.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERRIMACK/DUTTON/ARCAND
1999 BUILD CONDITIONS
date:10-28-1992 time:13:10:04
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=DUTTONV GEOMETRICS=DUTBGEO SIGNAL=DUTBSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	46	507	0	0	2	0	0.0	12.0	0.0	60
WB	0	379	0	0	2	0	0.0	12.0	0.0	50
NB	526	370	155	1	1	0	12.0	12.0	0.0	40
SB	0	0	219	0	0	2	0.0	0.0	12.0	40

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	22.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	22.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	14.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	14.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1								*	*	*	*						35.5	3	A
2	*	*													*	*	14.6	3	A
3	*	*				*						*				*	14.9	3	A
4				*				*				*				*	0.0	6	A

CYCLE= 80.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	46	507	0	.900	51	563	0
WB	0	379	0	.900	0	421	0
NB	526	370	155	.900	584	411	172
SB	0	0	219	.900	0	0	243

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT-TH	614	2	1.05	645	0.08	0.00
WB	TH	421	2	1.05	442	0.00	0.00
NB	LT	584	1	1.00	584	1.00	0.00
NB	TH-RT	583	1	1.00	583	0.00	0.30
SB	RT	243	2	1.05	256	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	0	421	0	100	100	0	0	2	0	421
NORTHBOUND	0	0	243	0	0	0	0	0	2	0

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.966	3067
WB	TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
NB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.859	1.000	1365
SB	RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	0.750	1.000	2382

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT-TH	645	3067	0.21	0.41	1246	0.52	
WB	TH	442	3176	0.14	0.19	592	0.75	*
NB	LT	584	1509	0.39	0.44	670	0.87	
NB	TH-RT	583	1365	0.43	0.44	606	0.96	*
SB	RT	256	2382	0.11	0.18	435	0.59	*

CYCLE= 80.0 LOST=15.0 SUM V/S CRIT= 0.67 TOTAL V/C= 0.83

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT-TH	0.52	0.41	80.0	13.57	1246	0.32	0.85	11.81	B	8.1	
WB	TH	0.75	0.19	80.0	23.39	592	3.60	0.85	22.94	C	7.6	
NB	LT	0.87	0.44	80.0	15.35	670	8.61	1.00	23.96	C	7.5	
NB	TH-RT	0.96	0.44	80.0	16.43	606	20.34	0.85	31.25	D	8.7	
SB	RT	0.59	0.18	80.0	22.76	435	1.52	0.85	20.64	C	4.4	

DIR	Delay	LOS
EB	11.81	B
WB	22.94	C
NB	27.60	D
SB	20.64	C

INTERSECTION DELAY = 22.01 INTERSECTION LOS=C

THE CYCLE LENGTH WITHIN THE BOUNDS OF 60 TO 80 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 60.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 51.6 SECONDS
for chosen cycle length 80.0
suggested timing phase 1 is 34.2 secs green, 3.0 secs yellow + red clear
suggested timing phase 2 is 8.6 secs green, 3.0 secs yellow + red clear
suggested timing phase 3 is 11.1 secs green, 3.0 secs yellow + red clear
suggested timing phase 4 is 0.0 secs green, 6.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERIMACK/WORTHEN/ARCAND
1992 NO-BUILD CONDITION
date:10-28-1992 time:13:35:19
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=DUTTONV GEOMETRICS=DUTBGEO SIGNAL=DUTBSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	0	0	0	0	0	0	0.0	0.0	0.0	0
WB	319	55	67	1	1	0	12.0	12.0	0.0	0
NB	19	323	0	0	1	0	0.0	12.0	0.0	0
SB	0	215	23	0	1	0	0.0	12.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1					*		*										24.0	29	P
2									*	*				*	*		36.0	29	P

CYCLE= 118.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	0	0	.900	51	563	0
WB	319	55	67	.900	354	61	74
NB	19	323	0	.900	21	359	0
SB	0	215	23	.900	0	239	26

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
WB	LT	354	1	1.00	354	1.00	0.00
WB	TH-RT	136	1	1.00	136	0.00	0.55
NB	LT-TH	380	1	1.00	380	0.06	0.00
SB	TH-RT	264	1	1.00	264	0.00	0.10

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
WESTBOUND	51	563	0	0	0	0	0	0	0	0
NORTHBOUND	0	239	26	100	100	100	0	1	0	264

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
WB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
WB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.825	1.000	1310
NB	LT-TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.961	1526
SB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.887	1.000	1408

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
NB	118	36	1	380	359	21	0.06	1	264	0.00

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
NB	1800	0.147	21.878	0.710	0.056	14.122	0.944	11.291	1.585	0.961	0.961

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
WB	LT	354	1509	0.23	0.20	307	1.15	*
WB	TH-RT	136	1310	0.10	0.00	0	0.00	
NB	LT-TH	380	1526	0.25	0.31	466	0.82	*
SB	TH-RT	264	1408	0.19	0.31	430	0.62	

CYCLE=118.0 LOST=58.0 SUM V/S CRIT= 0.48 TOTAL V/C= 0.95

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95%
WB	LT	1.15	0.20	118.0	37.19	307	102.76	1.00	139.95	F	18.4	
WB	TH-RT	0.00	0.00	118.0	0.00	0	0.00	1.00	0.00	A	4.4	
NB	LT-TH	0.82	0.31	118.0	28.83	466	7.47	1.00	36.31	D	8.7	
SB	TH-RT	0.62	0.31	118.0	26.66	430	1.88	1.00	28.54	D	6.0	

DIR	Delay	LOS
WB	101.23	F
NB	36.31	D
SB	28.54	D

INTERSECTION DELAY = 62.54 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 100 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 118.2 SECONDS
for chosen cycle length 65.0
suggested timing phase 1 is 15.3 secs green, 29.0 secs yellow + red clea
suggested timing phase 2 is 16.2 secs green, 29.0 secs yellow + red clea

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERIMACK/WORTHEN/ARCAND
1995 NO-BUILD CONDITION
Date:10-28-1992 time:13:46:54
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=WORVOL GEOMETRICS=WORGEO SIGNAL=WORSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	0	0	0	0	0	0	0.0	0.0	0.0	0
WB	343	60	72	1	1	0	12.0	12.0	0.0	0
NB	21	348	0	0	1	0	0.0	12.0	0.0	0
SB	0	232	24	0	1	0	0.0	12.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1					*		*										24.0	29	P
2									*	*				*	*		36.0	29	P

CYCLE= 118.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	0	0	.900	51	563	0
WB	343	60	72	.900	381	67	80
NB	21	348	0	.900	23	387	0
SB	0	232	24	.900	0	258	27

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
WB	LT	381	1	1.00	381	1.00	0.00
WB	TH-RT	147	1	1.00	147	0.00	0.55
NB	LT-TH	410	1	1.00	410	0.06	0.00
SB	TH-RT	284	1	1.00	284	0.00	0.09

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
WESTBOUND	51	563	0	0	0	0	0	0	0	0
NORTHBOUND	0	258	27	100	100	100	0	1	0	284

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
WB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
WB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.825	1.000	1310
NB	LT-TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.946	1503
SB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.887	1.000	1409

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
NB	118	36	1	410	387	23	0.06	1	284	0.00

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
NB	1800	0.158	20.610	0.697	0.057	15.390	0.943	12.029	1.614	0.946	0.946

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
WB	LT	381	1509	0.25	0.20	307	1.24	*
WB	TH-RT	147	1310	0.11	0.00	0	0.00	
NB	LT-TH	410	1503	0.27	0.31	458	0.89	*
SB	TH-RT	284	1409	0.20	0.31	430	0.66	

CYCLE=118.0 LOST=58.0 SUM V/S CRIT= 0.53 TOTAL V/C= 1.03

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
WB	LT	1.24	0.20	118.0	38.07	307	158.22	1.00	196.29	F	25.8	
WB	TH-RT	0.00	0.00	118.0	0.00	0	0.00	1.00	0.00	A	4.8	
NB	LT-TH	0.89	0.31	118.0	29.78	458	13.87	1.00	43.65	E	9.6	
SB	TH-RT	0.66	0.31	118.0	27.13	430	2.62	1.00	29.75	D	6.5	

DIR	Delay	LOS
WB	141.74	F
NB	43.65	E
SB	29.75	D

INTERSECTION DELAY = 82.77 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 100 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 129.8 SECONDS
for chosen cycle length 70.0
suggested timing phase 1 is 17.7 secs green, 29.0 secs yellow + red clear
suggested timing phase 2 is 19.1 secs green, 29.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERIMACK/WORTHEN/ARCAND
1996 NO-BUILD CONDITION
date:10-28-1992 time:13:50:20
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=WORVOL GEOMETRICS=WORGEO SIGNAL=WORSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	0	0	0	0	0	0	0.0	0.0	0.0	0
WB	352	61	74	1	1	0	12.0	12.0	0.0	0
NB	21	356	0	0	1	0	0.0	12.0	0.0	0
SB	0	238	25	0	1	0	0.0	12.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1					*		*										24.0	29	P
2									*	*				*	*		36.0	29	P

CYCLE= 118.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	0	0	.900	51	563	0
WB	352	61	74	.900	391	68	82
NB	21	356	0	.900	23	396	0
SB	0	238	25	.900	0	264	28

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
WB	LT	391	1	1.00	391	1.00	0.00
WB	TH-RT	150	1	1.00	150	0.00	0.55
NB	LT-TH	419	1	1.00	419	0.06	0.00
SB	TH-RT	292	1	1.00	292	0.00	0.10

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
WESTBOUND	51	563	0	0	0	0	0	0	0	0
NORTHBOUND	0	264	28	100	100	100	0	1	0	292

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
WB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
WB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.825	1.000	1310
NB	LT-TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.943	1498
SB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.887	1.000	1409

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
NB	118	36	1	419	396	23	0.06	1	292	0.00

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
NB	1800	0.162	20.108	0.692	0.056	15.892	0.944	12.403	1.625	0.943	0.943

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
WB	LT	391	1509	0.26	0.20	307	1.27	*
WB	TH-RT	150	1310	0.11	0.00	0	0.00	
NB	LT-TH	419	1498	0.28	0.31	457	0.92	*
SB	TH-RT	292	1409	0.21	0.31	430	0.68	

CYCLE=118.0 LOST=58.0 SUM V/S CRIT= 0.54 TOTAL V/C= 1.06

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
WB	LT	1.27	0.20	118.0	38.41	307	182.94	1.00	221.35	F	29.2	
WB	TH-RT	0.00	0.00	118.0	0.00	0	0.00	1.00	0.00	A	4.9	
NB	LT-TH	0.92	0.31	118.0	30.06	457	16.63	1.00	46.69	E	10.2	
SB	TH-RT	0.68	0.31	118.0	27.32	430	2.99	1.00	30.31	D	6.7	

DIR	Delay	LOS
WB	159.99	F
NB	46.69	E
SB	30.31	D

INTERSECTION DELAY = 91.83 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 134.0 SECONDS
for chosen cycle length 65.0
suggested timing phase 1 is 16.8 secs green, 29.0 secs yellow - red clear
suggested timing phase 2 is 18.2 secs green, 29.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERIMACK/WORTHEN/ARCAND
1999 NO-BUILD CONDITION
date:10-28-1992 time:13:52:57
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=WORVOL GEOMETRICS=WORGEO SIGNAL=WORSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	0	0	0	0	0	0	0.0	0.0	0.0	0
WB	379	66	79	1	1	0	12.0	12.0	0.0	0
NB	23	384	0	0	1	0	0.0	12.0	0.0	0
SB	0	256	27	0	1	0	0.0	12.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ	PARK			PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1					*		*										24.0	29	P
2									*	*				*	*		36.0	29	P

CYCLE= 118.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	0	0	.900	51	563	0
WB	379	66	79	.900	421	73	88
NB	23	384	0	.900	26	427	0
SB	0	256	27	.900	0	284	30

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
WB	LT	421	1	1.00	421	1.00	0.00
WB	TH-RT	161	1	1.00	161	0.00	0.54
NB	LT-TH	452	1	1.00	452	0.06	0.00
SB	TH-RT	314	1	1.00	314	0.00	0.10

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
WESTBOUND	51	563	0	0	0	0	0	0	0	0
NORTHBOUND	0	284	30	100	100	100	0	1	0	314

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
WB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
WB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.825	1.000	1311
NB	LT-TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.926	1470
SB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.887	1.000	1409

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
NB	118	36	1	452	427	26	0.06	1	314	0.00

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
NB	1800	0.175	18.643	0.678	0.057	17.357	0.943	13.236	1.658	0.926	0.926

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
WB	LT	421	1509	0.28	0.20	307	1.37	*
WB	TH-RT	161	1311	0.12	0.00	0	0.00	
NB	LT-TH	452	1470	0.31	0.31	449	1.01	*
SB	TH-RT	314	1409	0.22	0.31	430	0.73	

CYCLE=118.0 LOST=58.0 SUM V/S CRIT= 0.59 TOTAL V/C= 1.15

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
WB	LT	1.37	0.20	118.0	39.47	307	270.58	1.00	310.05	F	41.8	
WB	TH-RT	0.00	0.00	118.0	0.00	0	0.00	1.00	0.00	A	5.3	
NB	LT-TH	1.01	0.31	118.0	31.27	449	34.83	1.00	66.11	F	13.5	
SB	TH-RT	0.73	0.31	118.0	27.88	430	4.33	1.00	32.20	D	7.2	

DIR	Delay	LOS
WB	224.26	F
NB	66.11	F
SB	32.20	D

INTERSECTION DELAY =126.47 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 151.7 SECONDS
for chosen cycle length 65.0
suggested timing phase 1 is 18.1 secs green, 29.0 secs yellow + red clear
suggested timing phase 2 is 20.0 secs green, 29.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERIMACK/WORTHEN/ARCAND
1992 BUILD CONDITIONS
date:10-28-1992 time:14:04:07
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=WORBVOL GEOMETRICS=WORBGEO SIGNAL=WORBSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	0	0	0	0	0	0	0.0	0.0	0.0	0
WB	0	55	67	1	1	0	12.0	12.0	0.0	0
NB	19	323	0	0	1	0	0.0	12.0	0.0	0
SB	0	215	23	0	1	0	0.0	12.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1				*				*	*	*				*	*		53.0	0	A
2						*	*									*	15.0	0	A

CYCLE= 68.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	0	0	.900	51	563	0
WB	0	55	67	.900	0	61	74
NB	19	323	0	.900	21	359	0
SB	0	215	23	.900	0	239	26

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
WB	TH-RT	136	1	1.00	136	0.00	0.55
NB	LT-TH	380	1	1.00	380	0.06	0.00
SB	TH-RT	264	1	1.00	264	0.00	0.10

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
NORTHBOUND	0	239	26	100	100	100	0	1	0	264

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
WB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.825	1.000	1310
NB	LT-TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	1588
SB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.887	1.000	1408

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT
INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
NB	68	53	1	380	359	21	0.06	1	264	0.00

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
NB	1800	0.147	50.417	0.710	0.056	2.583	0.944	2.420	1.585	1.000	1.000

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
WB	TH-RT	136	1310	0.10	0.22	289	0.47	*
NB	LT-TH	380	1588	0.24	0.78	1238	0.31	*
SB	TH-RT	264	1408	0.19	0.78	1098	0.24	

CYCLE= 68.0 LOST= 0.0 SUM V/S CRIT= 0.34 TOTAL V/C= 0.34

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
WB	TH-RT	0.47	0.22	68.0	17.51	289	0.91	0.85	15.66	C	2.0	
NB	LT-TH	0.31	0.78	68.0	1.65	1238	0.05	0.85	1.44	A	1.6	
SB	TH-RT	0.24	0.78	68.0	1.55	1098	0.02	0.85	1.34	A	1.1	

DIR	Delay	LOS
WB	15.66	C
NB	1.44	A
SB	1.34	A

INTERSECTION DELAY = 3.88 INTERSECTION LOS=A

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 0.0 SECONDS
for chosen cycle length 80.0
suggested timing phase 1 is 19.1 secs green, 0.0 secs yellow + red clear
suggested timing phase 2 is 8.3 secs green, 0.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERIMACK/WORTHEN/ARCAND
1995 BUILD CONDITIONS
date:10-28-1992 time:14:08:45
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=WORBVOL GEOMETRICS=WORBGEO SIGNAL=WORBSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	0	0	0	0	0	0	0.0	0.0	0.0	0
WB	0	60	72	1	1	0	12.0	12.0	0.0	0
NB	21	348	0	0	1	0	0.0	12.0	0.0	0
SB	0	232	24	0	1	0	0.0	12.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1				*				*	*	*				*	*		53.0	0	A
2						*	*									*	15.0	0	A

CYCLE= 68.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	0	0	.900	51	563	0
WB	0	60	72	.900	0	67	80
NB	21	348	0	.900	23	387	0
SB	0	232	24	.900	0	258	27

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
WB	TH-RT	147	1	1.00	147	0.00	0.55
NB	LT-TH	410	1	1.00	410	0.06	0.00
SB	TH-RT	284	1	1.00	284	0.00	0.09

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
NORTHBOUND	0	258	27	100	100	100	0	1	0	284

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
WB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.825	1.000	1310
NB	LT-TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	1588
SB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.887	1.000	1409

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT
INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
NB	68	53	1	410	387	23	0.06	1	284	0.00

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
NB	1800	0.158	50.185	0.697	0.057	2.815	0.943	2.624	1.614	1.000	1.000

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
WB	TH-RT	147	1310	0.11	0.22	289	0.51	*
NB	LT-TH	410	1588	0.26	0.78	1238	0.33	*
SB	TH-RT	284	1409	0.20	0.78	1098	0.26	

CYCLE= 68.0 LOST= 0.0 SUM V/S CRIT= 0.37 TOTAL V/C= 0.37

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
WB	TH-RT	0.51	0.22	68.0	17.68	289	1.23	0.85	16.07	C	2.2	
NB	LT-TH	0.33	0.78	68.0	1.69	1238	0.06	0.85	1.49	A	1.7	
SB	TH-RT	0.26	0.78	68.0	1.58	1098	0.03	0.85	1.36	A	1.2	

DIR	Delay	LOS
WB	16.07	C
NB	1.49	A
SB	1.36	A

INTERSECTION DELAY = 3.99 INTERSECTION LOS=A

THE CYCLE LENGTH WITHIN THE BOUNDS OF 30 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 30.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 0.0 SECONDS
for chosen cycle length 80.0
suggested timing phase 1 is 20.7 secs green, 0.0 secs yellow + red clear
suggested timing phase 2 is 9.0 secs green, 0.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERIMACK/WORTHEN/ARCAND
1996 BUILD CONDITIONS
date:10-28-1992 time:14:11:41
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=WORBVOL GEOMETRICS=WORBGEO SIGNAL=WORBSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	0	0	0	0	0	0	0.0	0.0	0.0	0
WB	0	61	75	1	1	0	12.0	12.0	0.0	0
NB	21	356	0	0	1	0	0.0	12.0	0.0	0
SB	0	238	25	0	1	0	0.0	12.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1				*				*	*	*				*	*		53.0	0	A
2						*	*									*	15.0	0	A

CYCLE= 68.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	0	0	.900	51	563	0
WB	0	61	75	.900	0	68	83
NB	21	356	0	.900	23	396	0
SB	0	238	25	.900	0	264	28

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
WB	TH-RT	151	1	1.00	151	0.00	0.55
NB	LT-TH	419	1	1.00	419	0.06	0.00
SB	TH-RT	292	1	1.00	292	0.00	0.10

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
NORTHBOUND	0	264	28	100	100	100	0	1	0	292

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
WB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.824	1.000	1309
NB	LT-TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	1588
SB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.887	1.000	1409

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT
INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
NB	68	53	1	419	396	23	0.06	1	292	0.00

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
NB	1800	0.162	50.093	0.692	0.056	2.907	0.944	2.710	1.625	1.000	1.000

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
WB	TH-RT	151	1309	0.12	0.22	289	0.52	*
NB	LT-TH	419	1588	0.26	0.78	1238	0.34	*
SB	TH-RT	292	1409	0.21	0.78	1098	0.27	

CYCLE= 68.0 LOST= 0.0 SUM V/S CRIT= 0.38 TOTAL V/C= 0.38

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
WB	TH-RT	0.52	0.22	68.0	17.75	289	1.40	0.85	16.27	C	2.2	
NB	LT-TH	0.34	0.78	68.0	1.71	1238	0.07	0.85	1.51	A	1.7	
SB	TH-RT	0.27	0.78	68.0	1.59	1098	0.03	0.85	1.38	A	1.2	

DIR	Delay	LOS
WB	16.27	C
NB	1.51	A
SB	1.38	A

INTERSECTION DELAY = 4.05 INTERSECTION LOS=A

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 0.0 SECONDS
for chosen cycle length 80.0
suggested timing phase 1 is 21.1 secs green, 0.0 secs yellow + red clear
suggested timing phase 2 is 9.2 secs green, 0.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
MERIMACK/WORTHEN/ARCAND
1999 BUILD CONDITIONS
date:10-28-1992 time:14:14:38
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=WORBVOL GEOMETRICS=WORBGEO SIGNAL=WORBSIG
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	0	0	0	0	0	0	0.0	0.0	0.0	0
WB	0	66	79	1	1	0	12.0	12.0	0.0	0
NB	23	384	0	0	1	0	0.0	12.0	0.0	0
SB	0	256	27	0	1	0	0.0	12.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1				*				*	*	*				*	*		53.0	0	A
2						*	*									*	15.0	0	A

CYCLE= 68.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	0	0	.900	51	563	0
WB	0	66	79	.900	0	73	88
NB	23	384	0	.900	26	427	0
SB	0	256	27	.900	0	284	30

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
WB	TH-RT	161	1	1.00	161	0.00	0.54
NB	LT-TH	452	1	1.00	452	0.06	0.00
SB	TH-RT	314	1	1.00	314	0.00	0.10

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
NORTHBOUND	0	284	30	100	100	100	0	1	0	314

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
WB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.825	1.000	1311
NB	LT-TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	1588
SB	TH-RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.887	1.000	1409

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT
INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
NB	68	53	1	452	427	26	0.06	1	314	0.00

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
NB	1800	0.175	49.825	0.678	0.057	3.175	0.943	2.945	1.658	1.000	1.000

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
WB	TH-RT	161	1311	0.12	0.22	289	0.56	*
NB	LT-TH	452	1588	0.28	0.78	1238	0.37	*
SB	TH-RT	314	1409	0.22	0.78	1098	0.29	

CYCLE= 68.0 LOST= 0.0 SUM V/S CRIT= 0.41 TOTAL V/C= 0.41

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
WB	TH-RT	0.56	0.22	68.0	17.90	289	1.80	0.85	16.75	C	2.4	
NB	LT-TH	0.37	0.78	68.0	1.76	1238	0.09	0.85	1.57	A	1.9	
SB	TH-RT	0.29	0.78	68.0	1.62	1098	0.04	0.85	1.41	A	1.3	

DIR	Delay	LOS
WB	16.75	C
NB	1.57	A
SB	1.41	A

INTERSECTION DELAY = 4.15 INTERSECTION LOS=A

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 0.0 SECONDS
for chosen cycle length 80.0
suggested timing phase 1 is 22.8 secs green, 0.0 secs yellow - red clear
suggested timing phase 2 is 9.8 secs green, 0.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ARCAND/FRENCH
1992 BUILD CONDITIONS
date:10-29-1992 time:09:53:24
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=FRENBVOL GEOMETRICS=FRENBGEO SIGNAL=FRENBSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	442	78	128	0	2	1	0.0	12.0	12.0	0
WB	70	110	54	0	2	0	0.0	12.0	0.0	0
NB	100	250	59	2	1	0	12.0	14.0	0.0	0
SB	37	234	167	1	1	1	12.0	12.0	14.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3
WB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3
NB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3
SB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1													*	*	*		15.0	3	A
2			*						*	*	*						26.0	3	A
3	*	*	*												*		20.0	3	A
4					*	*	*										10.0	3	A
5				*				*				*				*	1.0	6	A

CYCLE= 90.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	442	78	128	.900	491	87	142
WB	70	110	54	.900	78	122	60
NB	100	250	59	.900	111	278	66
SB	37	234	167	.900	41	260	186

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT-TH	578	2	1.05	607	0.85	0.00
EB	RT	142	1	1.00	142	0.00	1.00
WB	LT-TH-RT	260	2	1.05	273	0.30	0.23
NB	LT	111	2	1.05	117	1.00	0.00
NB	TH-RT	343	1	1.00	343	0.00	0.19
SB	LT	41	1	1.00	41	1.00	0.00
SB	TH	260	1	1.00	260	0.00	0.00
SB	RT	186	1	1.00	186	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	78	122	60	0	0	0	0	2	0	0
WESTBOUND	491	87	142	0	0	0	0	2	1	0
NORTHBOUND	41	260	186	0	0	0	1	1	1	0
SOUTHBOUND	111	278	66	0	0	0	2	1	0	0

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
EB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350
WB	LT-TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.920	2922
NB	TH-RT	1800	1	1.067	0.980	1.000	1.000	1.000	0.900	0.874	1.000	1481
SB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
SB	TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	1588
SB	RT	1800	1	1.067	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1440

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT-TH	607	3176	0.19	0.22	706	0.86	*
EB	RT	142	1350	0.11	0.54	735	0.19	
WB	LT-TH-RT	273	3176	0.09	0.11	353	0.77	*
NB	LT	117	2922	0.04	0.29	844	0.14	
NB	TH-RT	343	1481	0.23	0.29	428	0.80	*
SB	LT	41	1509	0.03	0.17	251	0.16	
SB	TH	260	1588	0.16	0.17	265	0.98	*
SB	RT	186	1440	0.13	0.39	560	0.33	

CYCLE= 90.0 LOST=18.0 SUM V/S CRIT= 0.67 TOTAL V/C= 0.84

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT-TH	0.86	0.22	90.0	25.57	706	7.35	0.85	27.99	D	11.2	
EB	RT	0.19	0.54	90.0	7.93	735	0.02	0.85	6.76	B	1.6	
WB	LT-TH-RT	0.77	0.11	90.0	29.56	353	6.97	0.85	31.06	D	5.8	
NB	LT	0.14	0.29	90.0	18.01	844	0.01	1.00	18.02	C	2.0	
NB	TH-RT	0.80	0.29	90.0	22.51	428	7.26	0.85	25.31	D	6.1	
SB	LT	0.16	0.17	90.0	24.42	251	0.03	1.00	24.44	C	0.9	
SB	TH	0.98	0.17	90.0	28.40	265	37.81	0.85	56.28	E	6.8	
SB	RT	0.33	0.39	90.0	14.66	560	0.13	0.85	12.58	B	2.8	

DIR	Delay	LOS
EB	23.95	C
WB	31.06	D
NB	23.46	C
SB	36.93	D

INTERSECTION DELAY = 28.03 INTERSECTION LOS=D

THE CYCLE LENGTH WITHIN THE BOUNDS OF 90 TO 90 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 0.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 61.6 SECONDS
for chosen cycle length 90.0
suggested timing phase 1 is 17.5 secs green, 3.0 secs yellow + red clear
suggested timing phase 2 is 24.8 secs green, 3.0 secs yellow + red clear
suggested timing phase 3 is 20.4 secs green, 3.0 secs yellow + red clear
suggested timing phase 4 is 9.2 secs green, 3.0 secs yellow + red clear
suggested timing phase 5 is 0.0 secs green, 6.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ARCAND/FRENCH
1995 BUILD CONDITIONS
date:10-29-1992 time:09:42:58
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=FRENBVOL GEOMETRICS=FRENBGEO SIGNAL=FRENBSIG
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	476	84	138	0	2	1	0.0	12.0	12.0	0
WB	75	118	59	0	2	0	0.0	12.0	0.0	0
NB	108	269	64	2	1	0	12.0	14.0	0.0	0
SB	40	252	180	1	1	1	12.0	12.0	14.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3
WB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3
NB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3
SB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y-R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1													*	*	*		15.0	3	A
2			*						*	*	*						26.0	3	A
3	*	*	*												*		20.0	3	A
4					*	*	*										10.0	3	A
5				*				*				*				*	1.0	6	A

CYCLE= 90.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	476	84	138	.900	529	93	153
WB	75	118	59	.900	83	131	66
NB	108	269	64	.900	120	299	71
SB	40	252	180	.900	44	280	200

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT-TH	622	2	1.05	653	0.85	0.00
EB	RT	153	1	1.00	153	0.00	1.00
WB	LT-TH-RT	280	2	1.05	294	0.30	0.23
NB	LT	120	2	1.05	126	1.00	0.00
NB	TH-RT	370	1	1.00	370	0.00	0.19
SB	LT	44	1	1.00	44	1.00	0.00
SB	TH	280	1	1.00	280	0.00	0.00
SB	RT	200	1	1.00	200	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	83	131	66	0	0	0	0	2	0	0
WESTBOUND	529	93	153	0	0	0	0	2	1	0
NORTHBOUND	44	280	200	0	0	0	1	1	1	0
SOUTHBOUND	120	299	71	0	0	0	2	1	0	0

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
EB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350
WB	LT-TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.920	2922
NB	TH-RT	1800	1	1.067	0.980	1.000	1.000	1.000	0.900	0.874	1.000	1481
SB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
SB	TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	1588
SB	RT	1800	1	1.067	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1440

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT-TH	653	3176	0.21	0.22	706	0.93	*
EB	RT	153	1350	0.11	0.54	735	0.21	
WB	LT-TH-RT	294	3176	0.09	0.11	353	0.83	*
NB	LT	126	2922	0.04	0.29	844	0.15	
NB	TH-RT	370	1481	0.25	0.29	428	0.86	*
SB	LT	44	1509	0.03	0.17	251	0.18	
SB	TH	280	1588	0.18	0.17	265	1.06	*
SB	RT	200	1440	0.14	0.39	560	0.36	
		2,120						

CYCLE= 90.0 LOST=18.0 SUM V/S CRIT= 0.72 TOTAL V/C= 0.91

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT-TH	0.93	0.22	90.0	26.05	706	13.10	0.85	33.28	D	12.1	
EB	RT	0.21	0.54	90.0	8.01	735	0.02	0.85	6.82	B	1.7	
WB	LT-TH-RT	0.83	0.11	90.0	29.78	353	10.71	0.85	34.42	D	6.2	
NB	LT	0.15	0.29	90.0	18.07	844	0.01	1.00	18.08	C	2.1	
NB	TH-RT	0.86	0.29	90.0	23.06	428	11.63	0.85	29.48	D	6.6	
SB	LT	0.18	0.17	90.0	24.47	251	0.04	1.00	24.51	C	0.9	
SB	TH	1.06	0.17	90.0	28.83	265	61.39	0.85	76.69	F	8.9	
SB	RT	0.36	0.39	90.0	14.83	560	0.17	0.85	12.76	B	3.1	

DIR	Delay	LOS
EB	28.25	D
WB	34.42	D
NB	26.59	D
SB	47.89	E

INTERSECTION DELAY = 33.57 INTERSECTION LOS=D

THE CYCLE LENGTH WITHIN THE BOUNDS OF 90 TO 90 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 0.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 75.8 SECONDS
for chosen cycle length 90.0
suggested timing phase 1 is 17.5 secs green, 3.0 secs yellow + red clear
suggested timing phase 2 is 24.8 secs green, 3.0 secs yellow + red clear
suggested timing phase 3 is 20.4 secs green, 3.0 secs yellow + red clear
suggested timing phase 4 is 9.2 secs green, 3.0 secs yellow + red clear
suggested timing phase 5 is 0.0 secs green, 6.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ARCAND/FRENCH
1996 BUILD CONDITIONS
date:10-29-1992 time:09:47:01
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=FRENBVOL GEOMETRICS=FRENBGEO SIGNAL=FRENBSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	488	86	141	0	2	1	0.0	12.0	12.0	0
WB	77	121	60	0	2	0	0.0	12.0	0.0	0
NB	111	276	66	2	1	0	12.0	14.0	0.0	0
SB	41	258	184	1	1	1	12.0	12.0	14.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3
WB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3
NB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3
SB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1													*	*	*		15.0	3	A
2			*						*	*	*						26.0	3	A
3	*	*	*												*		20.0	3	A
4					*	*	*										10.0	3	A
5				*				*				*				*	1.0	6	A

CYCLE= 90.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	488	86	141	.900	542	96	157
WB	77	121	60	.900	86	134	67
NB	111	276	66	.900	123	307	73
SB	41	258	184	.900	46	287	204

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT-TH	638	2	1.05	670	0.85	0.00
EB	RT	157	1	1.00	157	0.00	1.00
WB	LT-TH-RT	287	2	1.05	301	0.30	0.23
NB	LT	123	2	1.05	130	1.00	0.00
NB	TH-RT	380	1	1.00	380	0.00	0.19
SB	LT	46	1	1.00	46	1.00	0.00
SB	TH	287	1	1.00	287	0.00	0.00
SB	RT	204	1	1.00	204	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	86	134	67	0	0	0	0	2	0	0
WESTBOUND	542	96	157	0	0	0	0	2	1	0
NORTHBOUND	46	287	204	0	0	0	1	1	1	0
SOUTHBOUND	123	307	73	0	0	0	2	1	0	0

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
EB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350
WB	LT-TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.920	2922
NB	TH-RT	1800	1	1.067	0.980	1.000	1.000	1.000	0.900	0.874	1.000	1481
SB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
SB	TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	1588
SB	RT	1800	1	1.067	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1440

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT-TH	670	3176	0.21	0.22	706	0.95	*
EB	RT	157	1350	0.12	0.54	735	0.21	
WB	LT-TH-RT	301	3176	0.09	0.11	353	0.85	*
NB	LT	130	2922	0.04	0.29	844	0.15	
NB	TH-RT	380	1481	0.26	0.29	428	0.89	*
SB	LT	46	1509	0.03	0.17	251	0.18	
SB	TH	287	1588	0.18	0.17	265	1.08	*
SB	RT	204	1440	0.14	0.39	560	0.37	

CYCLE= 90.0 LOST=18.0 SUM V/S CRIT= 0.74 TOTAL V/C= 0.93

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT-TH	0.95	0.22	90.0	26.22	706	16.20	0.85	36.05	D	12.6	
EB	RT	0.21	0.54	90.0	8.03	735	0.02	0.85	6.84	B	1.8	
WB	LT-TH-RT	0.85	0.11	90.0	29.85	353	12.39	0.85	35.90	D	6.4	
NB	LT	0.15	0.29	90.0	18.10	844	0.01	1.00	18.10	C	2.2	
NB	TH-RT	0.89	0.29	90.0	23.27	428	13.95	0.85	31.63	D	6.8	
SB	LT	0.18	0.17	90.0	24.49	251	0.04	1.00	24.53	C	0.9	
SB	TH	1.08	0.17	90.0	28.98	265	71.40	0.85	85.33	F	9.3	
SB	RT	0.37	0.39	90.0	14.89	560	0.19	0.85	12.81	B	3.1	

DIR	Delay	LOS
EB	30.52	D
WB	35.90	D
NB	28.19	D
SB	52.54	E

INTERSECTION DELAY = 36.16 INTERSECTION LOS=D

THE CYCLE LENGTH WITHIN THE BOUNDS OF 90 TO 90 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 0.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 82.5 SECONDS
for chosen cycle length 90.0
suggested timing phase 1 is 17.5 secs green, 3.0 secs yellow + red clear
suggested timing phase 2 is 24.9 secs green, 3.0 secs yellow + red clear
suggested timing phase 3 is 20.4 secs green, 3.0 secs yellow + red clear
suggested timing phase 4 is 9.2 secs green, 3.0 secs yellow + red clear
suggested timing phase 5 is 0.0 secs green, 6.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ARCAND/FRENCH
1999 BUILD CONDITIONS
date:10-29-1992 time:09:50:13
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=FRENBVOL GEOMETRICS=FRENBGEO SIGNAL=FRENBSIG
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	525	93	152	0	2	1	0.0	12.0	12.0	0
WB	83	130	65	0	2	0	0.0	12.0	0.0	0
NB	119	297	71	2	1	0	12.0	14.0	0.0	0
SB	44	278	199	1	1	1	12.0	12.0	14.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3
WB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3
NB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3
SB	0.0%	4.0%	N	0	0	.900	0	Y	1.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1													*	*	*		15.0	3	A
2			*						*	*	*						26.0	3	A
3	*	*	*												*		20.0	3	A
4					*	*	*										10.0	3	A
5				*				*				*				*	1.0	6	A

CYCLE= 90.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	525	93	152	.900	583	103	169
WB	83	130	65	.900	92	144	72
NB	119	297	71	.900	132	330	79
SB	44	278	199	.900	49	309	221

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT-TH	687	2	1.05	721	0.85	0.00
EB	RT	169	1	1.00	169	0.00	1.00
WB	LT-TH-RT	309	2	1.05	324	0.30	0.23
NB	LT	132	2	1.05	139	1.00	0.00
NB	TH-RT	409	1	1.00	409	0.00	0.19
SB	LT	49	1	1.00	49	1.00	0.00
SB	TH	309	1	1.00	309	0.00	0.00
SB	RT	221	1	1.00	221	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	92	144	72	0	0	0	0	2	0	0
WESTBOUND	583	103	169	0	0	0	0	2	1	0
NORTHBOUND	49	309	221	0	0	0	1	1	1	0
SOUTHBOUND	132	330	79	0	0	0	2	1	0	0

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
EB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350
WB	LT-TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.920	2922
NB	TH-RT	1800	1	1.067	0.980	1.000	1.000	1.000	0.900	0.874	1.000	1481
SB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
SB	TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	1588
SB	RT	1800	1	1.067	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1440

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT-TH	721	3176	0.23	0.22	706	1.02	*
EB	RT	169	1350	0.13	0.54	735	0.23	
WB	LT-TH-RT	324	3176	0.10	0.11	353	0.92	*
NB	LT	139	2922	0.05	0.29	844	0.16	
NB	TH-RT	409	1481	0.28	0.29	428	0.96	*
SB	LT	49	1509	0.03	0.17	251	0.19	
SB	TH	309	1588	0.19	0.17	265	1.17	*
SB	RT	221	1440	0.15	0.39	560	0.39	

CYCLE= 90.0 LOST=18.0 SUM V/S CRIT= 0.80 TOTAL V/C= 1.00

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT-TH	1.02	0.22	90.0	26.76	706	31.60	0.85	49.61	E	16.1	
EB	RT	0.23	0.54	90.0	8.11	735	0.03	0.85	6.92	B	1.9	
WB	LT-TH-RT	0.92	0.11	90.0	30.10	353	20.24	0.85	42.79	E	7.1	
NB	LT	0.16	0.29	90.0	18.16	844	0.01	1.00	18.17	C	2.4	
NB	TH-RT	0.96	0.29	90.0	23.89	428	23.74	0.85	40.48	E	8.2	
SB	LT	0.19	0.17	90.0	24.55	251	0.05	1.00	24.60	C	1.0	
SB	TH	1.17	0.17	90.0	29.48	265	113.21	0.85	121.29	F	13.6	
SB	RT	0.39	0.39	90.0	15.09	560	0.25	0.85	13.04	B	3.4	

DIR	Delay	LOS
EB	41.51	E
WB	42.79	E
NB	34.83	D
SB	71.78	F

INTERSECTION DELAY = 47.61 INTERSECTION LOS=E

THE CYCLE LENGTH WITHIN THE BOUNDS OF 90 TO 90 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 0.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 113.8 SECONDS
for chosen cycle length 90.0
suggested timing phase 1 is 17.5 secs green, 3.0 secs yellow + red clear
suggested timing phase 2 is 24.9 secs green, 3.0 secs yellow + red clear
suggested timing phase 3 is 20.4 secs green, 3.0 secs yellow + red clear
suggested timing phase 4 is 9.2 secs green, 3.0 secs yellow + red clear
suggested timing phase 5 is 0.0 secs green, 6.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ARCAND/FRENCH
1992 NO-BUILD CONDITION
date:10-29-1992 time:08:39:31
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=frenvol GEOMETRICS=frengeo SIGNAL=frensig
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	442	78	128	1	1	1	12.0	12.0	12.0	0
WB	70	110	54	0	2	0	0.0	12.0	0.0	0
NB	100	250	59	1	2	0	12.0	12.0	0.0	0
SB	37	234	167	0	2	1	0.0	12.0	12.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ	PARK			PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y-R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*		*	*	*										13.0	3	P
2									*	*	*						10.0	0	P
3									*	*	*		*	*	*		18.0	3	P

CYCLE= 47.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	442	78	128	.900	491	87	142
WB	70	110	54	.900	78	122	60
NB	100	250	59	.900	111	278	66
SB	37	234	167	.900	41	260	186

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	491	1	1.00	491	1.00	0.00
EB	TH	87	1	1.00	87	0.00	0.00
EB	RT	142	1	1.00	142	0.00	1.00
WB	LT-TH-RT	260	2	1.05	273	0.30	0.23
NB	LT	111	1	1.00	111	1.00	0.00
NB	TH-RT	343	2	1.05	360	0.00	0.19
SB	LT-TH	301	2	1.05	316	0.14	0.00
SB	RT	186	1	1.00	186	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	78	122	60	100	100	100	0	2	0	260
WESTBOUND	491	87	142	100	100	0	1	1	1	87
NORTHBOUND	41	260	186	100	100	0	0	2	1	301
SOUTHBOUND	111	278	66	64	64	64	1	2	0	221

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.789	1254
EB	TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	1588
EB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350
WB	LT-TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
NB	TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
SB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.998	3170
SB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
EB	47	13	1	491	229	491	1.00	2	260	0.30
WB	47	13	2	260	260	78	0.30	1	87	0.00
SB	47	18	2	301	487	41	0.14	2	221	0.00

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	GE	El	Fm	Flt
EB	3102	0.084	9.889	0.713	1.000	3.111	0.000	0.000	1.579	0.789	0.789
WB	1800	0.048	11.280	0.821	0.582	1.720	0.418	0.758	1.371	1.000	1.000
SB	3600	0.061	16.106	0.737	0.287	1.894	0.713	1.363	1.526	0.996	0.998

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	491	1254	0.39	0.28	347	1.42	*
EB	TH	87	1588	0.05	0.28	439	0.20	
EB	RT	142	1350	0.11	0.28	373	0.38	
WB	LT-TH-RT	273	3176	0.09	0.28	879	0.31	
NB	LT	111	1509	0.03	0.21	767	0.14	*
NB	TH-RT	360	3176	0.11	0.60	1892	0.19	
SB	LT-TH	316	3170	0.10	0.38	1214	0.26	
SB	RT	186	1350	0.14	0.38	517	0.36	*

CYCLE= 47.0 LOST= 6.0 SUM V/S CRIT= 0.56 TOTAL V/C= 0.64

FOR THE NORTHBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AND RATIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR 135 LEFT TURNS ON THE CHANGE INTERVAL AND 311 ON THE PERMISSIVE PHASE

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95%
EB	LT	1.42	0.28	47.0	15.36	347	313.72	1.00	329.09	F	47.2	
EB	TH	0.20	0.28	47.0	9.89	439	0.03	1.00	9.92	B	0.8	
EB	RT	0.38	0.28	47.0	10.45	373	0.33	1.00	10.77	B	1.3	
WB	LT-TH-RT	0.31	0.28	47.0	10.23	879	0.07	1.00	10.29	B	2.5	
NB	LT	0.14	0.60	47.0	3.19	767	0.01	1.00	3.20	A	1.1	
NB	TH-RT	0.19	0.60	47.0	3.29	1892	0.01	1.00	3.30	A	1.8	
SB	LT-TH	0.26	0.38	47.0	7.55	1214	0.03	1.00	7.58	B	2.4	
SB	RT	0.36	0.38	47.0	7.88	517	0.19	1.00	8.07	B	1.5	

DIR	Delay	LOS
EB	227.79	F
WB	10.29	B
NB	3.28	A
SB	7.76	B

INTERSECTION DELAY = 87.60 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 14.6 SECONDS
for chosen cycle length 65.0
suggested timing phase 1 is 25.5 secs green, 3.0 secs yellow + red clear
suggested timing phase 2 is 2.0 secs green, 0.0 secs yellow + red clear
suggested timing phase 3 is 8.9 secs green, 3.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ARCAND/FRENCH
1995 NO-BUILD CONDITION
date:10-29-1992 time:08:47:00
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=frenvol GEOMETRICS=frengeo SIGNAL=frensig
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	476	84	138	1	1	1	12.0	12.0	12.0	0
WB	75	118	59	0	2	0	0.0	12.0	0.0	0
NB	108	269	64	1	2	0	12.0	12.0	0.0	0
SB	40	252	180	0	2	1	0.0	12.0	12.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y-R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*		*	*	*										13.0	3	P
2									*	*	*						10.0	0	P
3									*	*	*		*	*	*		18.0	3	P

CYCLE= 47.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	476	84	138	.900	529	93	153
WB	75	118	59	.900	83	131	66
NB	108	269	64	.900	120	299	71
SB	40	252	180	.900	44	280	200

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	529	1	1.00	529	1.00	0.00
EB	TH	93	1	1.00	93	0.00	0.00
EB	RT	153	1	1.00	153	0.00	1.00
WB	LT-TH-RT	280	2	1.05	294	0.30	0.23
NB	LT	120	1	1.00	120	1.00	0.00
NB	TH-RT	370	2	1.05	388	0.00	0.19
SB	LT-TH	324	2	1.05	341	0.14	0.00
SB	RT	200	1	1.00	200	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	83	131	66	100	100	100	0	2	0	280
WESTBOUND	529	93	153	100	100	0	1	1	1	93
NORTHBOUND	44	280	200	100	100	0	0	2	1	324
SOUTHBOUND	120	299	71	64	64	64	1	2	0	238

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.767	1219
EB	TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	1588
EB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350
WB	LT-TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
NB	TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
SB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.994	3158
SB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
EB	47	13	1	529	247	529	1.00	2	280	0.30
WB	47	13	2	280	280	83	0.30	1	93	0.00
SB	47	18	2	324	524	44	0.14	2	238	0.00

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
EB	3085	0.091	9.606	0.700	1.000	3.394	0.000	0.000	1.607	0.767	0.767
WB	1800	0.052	11.141	0.817	0.582	1.859	0.418	0.798	1.378	1.000	1.000
SB	3600	0.066	15.948	0.726	0.290	2.052	0.710	1.450	1.549	0.988	0.994

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	529	1219	0.43	0.28	337	1.57	*
EB	TH	93	1588	0.06	0.28	439	0.21	
EB	RT	153	1350	0.11	0.28	373	0.41	
WB	LT-TH-RT	294	3176	0.09	0.28	879	0.33	
NB	LT	120	1509	0.03	0.21	755	0.16	*
NB	TH-RT	388	3176	0.12	0.60	1892	0.21	
SB	LT-TH	341	3158	0.11	0.38	1209	0.28	
SB	RT	200	1350	0.15	0.38	517	0.39	*

CYCLE= 47.0 LOST= 6.0 SUM V/S CRIT= 0.62 TOTAL V/C= 0.[illegible]

FOR THE NORTHBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AN
RATIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR
135 LEFT TURNS ON THE CHANGE INTERVAL AND 299 ON THE PERMISSIVE PHASE

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95%
EB	LT	1.57	0.28	47.0	16.51	337	510.63	1.00	527.14	F	79.9	
EB	TH	0.21	0.28	47.0	9.93	439	0.04	1.00	9.97	B	0.9	
EB	RT	0.41	0.28	47.0	10.54	373	0.43	1.00	10.97	B	1.4	
WB	LT-TH-RT	0.33	0.28	47.0	10.30	879	0.09	1.00	10.39	B	2.6	
NB	LT	0.16	0.60	47.0	3.22	755	0.01	1.00	3.23	A	1.2	
NB	TH-RT	0.21	0.60	47.0	3.33	1892	0.01	1.00	3.33	A	2.0	
SB	LT-TH	0.28	0.38	47.0	7.62	1209	0.04	1.00	7.66	B	2.6	
SB	RT	0.39	0.38	47.0	7.98	517	0.25	1.00	8.23	B	1.6	

DIR	Delay	LOS
EB	362.85	F
WB	10.39	B
NB	3.31	A
SB	7.87	B

INTERSECTION DELAY =137.06 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 17.1 SECONDS
for chosen cycle length 65.0
suggested timing phase 1 is 28.2 secs green, 3.0 secs yellow + red clear
suggested timing phase 2 is 2.2 secs green, 0.0 secs yellow - red clear
suggested timing phase 3 is 9.6 secs green, 3.0 secs yellow - red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ARCAND/FRENCH
1996 NO-BUILD CONDITION
date:10-29-1992 time:08:51:31
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=frenvol GEOMETRICS=frengeo SIGNAL=frensig
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	488	86	141	1	1	1	12.0	12.0	12.0	0
WB	77	121	60	0	2	0	0.0	12.0	0.0	0
NB	111	276	66	1	2	0	12.0	12.0	0.0	0
SB	41	258	184	0	2	1	0.0	12.0	12.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y-R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*		*	*	*										13.0	3	P
2									*	*	*						10.0	0	P
3									*	*	*		*	*	*		18.0	3	P

CYCLE= 47.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	488	86	141	.900	542	96	157
WB	77	121	60	.900	86	134	67
NB	111	276	66	.900	123	307	73
SB	41	258	184	.900	46	287	204

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	542	1	1.00	542	1.00	0.00
EB	TH	96	1	1.00	96	0.00	0.00
EB	RT	157	1	1.00	157	0.00	1.00
WB	LT-TH-RT	287	2	1.05	301	0.30	0.23
NB	LT	123	1	1.00	123	1.00	0.00
NB	TH-RT	380	2	1.05	399	0.00	0.19
SB	LT-TH	332	2	1.05	349	0.14	0.00
SB	RT	204	1	1.00	204	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	86	134	67	100	100	100	0	2	0	287
WESTBOUND	542	96	157	100	100	0	1	1	1	96
NORTHBOUND	46	287	204	100	100	0	0	2	1	332
SOUTHBOUND	123	307	73	64	64	64	1	2	0	244

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.760	1207
EB	TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	1588
EB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350
WB	LT-TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
NB	TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
SB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.993	3153
SB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
EB	47	13	1	542	252	542	1.00	2	287	0.30
WB	47	13	2	287	287	86	0.30	1	96	0.00
SB	47	18	2	332	537	46	0.14	2	244	0.00

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
EB	3078	0.093	9.508	0.696	1.000	3.492	0.000	0.000	1.617	0.760	0.760
WB	1800	0.053	11.094	0.815	0.585	1.906	0.415	0.805	1.380	1.000	1.000
SB	3600	0.068	15.339	0.722	0.292	2.111	0.708	1.482	1.557	0.985	0.993

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	542	1207	0.45	0.28	334	1.62	*
EB	TH	96	1588	0.06	0.28	439	0.22	
EB	RT	157	1350	0.12	0.28	373	0.42	
WB	LT-TH-RT	301	3176	0.09	0.28	879	0.34	
NB	LT	123	1509	0.03	0.21	751	0.16	*
NB	TH-RT	399	3176	0.13	0.60	1892	0.21	
SB	LT-TH	349	3153	0.11	0.38	1207	0.29	
SB	RT	204	1350	0.15	0.38	517	0.40	*

CYCLE= 47.0 LOST= 6.0 SUM V/S CRIT= 0.64 TOTAL V/C= 0.73

FOR THE NORTHBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AN
RATIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR
135 LEFT TURNS ON THE CHANGE INTERVAL AND 295 ON THE PERMISSIVE PHASE

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95%
EB	LT	1.62	0.28	47.0	16.97	334	596.41	1.00	613.38	F	94.9	
EB	TH	0.22	0.28	47.0	9.94	439	0.04	1.00	9.99	B	0.9	
EB	RT	0.42	0.28	47.0	10.57	373	0.47	1.00	11.04	B	1.5	
WB	LT-TH-RT	0.34	0.28	47.0	10.32	879	0.10	1.00	10.42	B	2.7	
NB	LT	0.16	0.60	47.0	3.24	751	0.01	1.00	3.24	A	1.3	
NB	TH-RT	0.21	0.60	47.0	3.34	1892	0.01	1.00	3.35	A	2.0	
SB	LT-TH	0.29	0.38	47.0	7.65	1207	0.04	1.00	7.68	B	2.7	
SB	RT	0.40	0.38	47.0	8.01	517	0.27	1.00	8.28	B	1.6	

DIR	Delay	LOS
EB	422.02	F
WB	10.42	B
NB	3.32	A
SB	7.91	B

INTERSECTION DELAY =158.69 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 100 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 18.1 SECONDS
for chosen cycle length 65.0
suggested timing phase 1 is 29.2 secs green, 3.0 secs yellow + red clear
suggested timing phase 2 is 2.3 secs green. 0.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ARCAND/FRENCH
1999 NO-BUILD CONDITION
date:10-29-1992 time:08:55:12
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=frenvol GEOMETRICS=frengeo SIGNAL=frensig
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	525	93	152	1	1	1	12.0	12.0	12.0	0
WB	83	130	65	0	2	0	0.0	12.0	0.0	0
NB	119	297	71	1	2	0	12.0	12.0	0.0	0
SB	44	278	199	0	2	1	0.0	12.0	12.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*		*	*	*										13.0	3	P
2									*	*	*						10.0	0	P
3									*	*	*		*	*	*		18.0	3	P

CYCLE= 47.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	525	93	152	.900	583	103	169
WB	83	130	65	.900	92	144	72
NB	119	297	71	.900	132	330	79
SB	44	278	199	.900	49	309	221

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	583	1	1.00	583	1.00	0.00
EB	TH	103	1	1.00	103	0.00	0.00
EB	RT	169	1	1.00	169	0.00	1.00
WB	LT-TH-RT	309	2	1.05	324	0.30	0.23
NB	LT	132	1	1.00	132	1.00	0.00
NB	TH-RT	409	2	1.05	429	0.00	0.19
SB	LT-TH	358	2	1.05	376	0.14	0.00
SB	RT	221	1	1.00	221	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	92	144	72	100	100	100	0	2	0	309
WESTBOUND	583	103	169	100	100	0	1	1	1	103
NORTHBOUND	49	309	221	100	100	0	0	2	1	358
SOUTHBOUND	132	330	79	64	64	64	1	2	0	263

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.736	1168
EB	TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	1588
EB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350
WB	LT-TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.997	3166
NB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
NB	TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
SB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.988	3140
SB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
EB	47	13	1	583	272	583	1.00	2	309	0.30
WB	47	13	2	309	309	92	0.30	1	103	0.00
SB	47	18	2	358	579	49	0.14	2	263	0.00

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
EB	3056	0.101	9.177	0.682	1.000	3.823	0.000	0.000	1.650	0.736	0.736
WB	1800	0.057	10.929	0.810	0.589	2.071	0.411	0.839	1.388	0.993	0.997
SB	3600	0.073	15.716	0.711	0.294	2.284	0.706	1.577	1.583	0.977	0.988

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	583	1168	0.50	0.28	323	1.81	*
EB	TH	103	1588	0.07	0.28	439	0.24	
EB	RT	169	1350	0.13	0.28	373	0.45	
WB	LT-TH-RT	324	3166	0.10	0.28	876	0.37	
NB	LT	132	1509	0.04	0.21	738	0.18	*
NB	TH-RT	429	3176	0.14	0.60	1892	0.23	
SB	LT-TH	376	3140	0.12	0.38	1202	0.31	
SB	RT	221	1350	0.16	0.38	517	0.43	*

CYCLE= 47.0 LOST= 6.0 SUM V/S CRIT= 0.70 TOTAL V/C= 0.80

FOR THE NORTHBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AN
RATIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR
135 LEFT TURNS ON THE CHANGE INTERVAL AND 282 ON THE PERMISSIVE PHASE

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95%
EB	LT	1.81	0.28	47.0	18.67	323	938.01	1.00	956.67	F	157.8	
EB	TH	0.24	0.28	47.0	10.00	439	0.05	1.00	10.05	B	1.0	
EB	RT	0.45	0.28	47.0	10.68	373	0.62	1.00	11.30	B	1.6	
WB	LT-TH-RT	0.37	0.28	47.0	10.41	876	0.13	1.00	10.54	B	2.9	
NB	LT	0.18	0.60	47.0	3.27	738	0.01	1.00	3.28	A	1.4	
NB	TH-RT	0.23	0.60	47.0	3.37	1892	0.01	1.00	3.39	A	2.2	
SB	LT-TH	0.31	0.38	47.0	7.72	1202	0.05	1.00	7.77	B	2.9	
SB	RT	0.43	0.38	47.0	8.13	517	0.36	1.00	8.49	B	1.8	

DIR	Delay	LOS
EB	655.72	F
WB	10.54	B
NB	3.36	A
SB	8.04	B

INTERSECTION DELAY =244.25 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 100 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 22.9 SECONDS
for chosen cycle length 65.0
suggested timing phase 1 is 32.5 secs green, 3.0 secs yellow + red clear
suggested timing phase 2 is 2.5 secs green, 0.0 secs yellow + red clear
suggested timing phase 3 is 10.6 secs green, 3.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
ARCAND/FRENCH
1999 NO-BUILD CONDITION
date:10-29-1992 time:08:55:12
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=frenvol GEOMETRICS=frengeo SIGNAL=frensig
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	525	93	152	1	1	1	12.0	12.0	12.0	0
WB	83	130	65	0	2	0	0.0	12.0	0.0	0
NB	119	297	71	1	2	0	12.0	12.0	0.0	0
SB	44	278	199	0	2	1	0.0	12.0	12.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
WB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
NB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3
SB	0.0%	4.0%	N	0	0	.900	5	Y	7.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*		*	*	*										13.0	3	P
2									*	*	*						10.0	0	P
3									*	*	*		*	*	*		18.0	3	P

CYCLE= 47.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	525	93	152	.900	583	103	169
WB	83	130	65	.900	92	144	72
NB	119	297	71	.900	132	330	79
SB	44	278	199	.900	49	309	221

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	583	1	1.00	583	1.00	0.00
EB	TH	103	1	1.00	103	0.00	0.00
EB	RT	169	1	1.00	169	0.00	1.00
WB	LT-TH-RT	309	2	1.05	324	0.30	0.23
NB	LT	132	1	1.00	132	1.00	0.00
NB	TH-RT	409	2	1.05	429	0.00	0.19
SB	LT-TH	358	2	1.05	376	0.14	0.00
SB	RT	221	1	1.00	221	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	92	144	72	100	100	100	0	2	0	309
WESTBOUND	583	103	169	100	100	0	1	1	1	103
NORTHBOUND	49	309	221	100	100	0	0	2	1	358
SOUTHBOUND	132	330	79	64	64	64	1	2	0	263

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.760	1207
EB	TH	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	1588
EB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350
WB	LT-TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
NB	LT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.950	1509
NB	TH-RT	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	1.000	3176
SB	LT-TH	1800	2	1.000	0.980	1.000	1.000	1.000	0.900	1.000	0.993	3153
SB	RT	1800	1	1.000	0.980	1.000	1.000	1.000	0.900	0.850	1.000	1350

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
EB	47	13	1	542	252	542	1.00	2	287	0.00
WB	47	13	2	287	287	86	0.30	1	96	0.00
SB	47	18	2	332	537	46	0.14	2	244	0.00

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
EB	3078	0.093	9.508	0.696	1.000	3.492	0.000	0.000	1.617	0.760	0.760
WB	1800	0.053	11.094	0.815	0.585	1.906	0.415	0.805	1.380	1.000	1.000
SB	3600	0.068	15.883	0.722	0.292	2.111	0.708	1.432	1.557	0.985	0.993

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	542	1207	0.45	0.28	334	1.62	*
EB	TH	96	1588	0.06	0.28	439	0.22	
EB	RT	157	1350	0.12	0.28	373	0.42	
WB	LT-TH-RT	301	3176	0.09	0.28	879	0.34	
NB	LT	123	1509	0.03	0.21	751	0.16	*
NB	TH-RT	399	3176	0.13	0.60	1892	0.21	
SB	LT-TH	349	3153	0.11	0.38	1207	0.29	
SB	RT	204	1350	0.15	0.38	517	0.40	*

CYCLE= 47.0 LOST= 6.0 SUM V/S CRIT= 0.64 TOTAL V/C= 0.73

FOR THE NORTHBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AN
RATIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR
135 LEFT TURNS ON THE CHANGE INTERVAL AND 295 ON THE PERMISSIVE PHASE

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT	1.62	0.28	47.0	16.97	334	596.41	1.00	613.38	F	94.9	
EB	TH	0.22	0.28	47.0	9.94	439	0.04	1.00	9.99	B	0.9	
EB	RT	0.42	0.28	47.0	10.57	373	0.47	1.00	11.04	B	1.5	
WB	LT-TH-RT	0.34	0.28	47.0	10.32	879	0.10	1.00	10.42	B	2.7	
NB	LT	0.16	0.60	47.0	3.24	751	0.01	1.00	3.24	A	1.3	
NB	TH-RT	0.21	0.60	47.0	3.34	1892	0.01	1.00	3.35	A	2.0	
SB	LT-TH	0.29	0.38	47.0	7.65	1207	0.04	1.00	7.68	B	2.7	
SB	RT	0.40	0.38	47.0	8.01	517	0.27	1.00	8.28	B	1.6	

DIR	Delay	LOS
EB	422.02	F
WB	10.42	B
NB	3.32	A
SB	7.91	B

INTERSECTION DELAY =158.69 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 100 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 50.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 18.1 SECONDS
for chosen cycle length 65.0
suggested timing phase 1 is 29.2 secs green, 3.0 secs yellow + red clear
suggested timing phase 2 is 2.3 secs green, 0.0 secs yellow + red clear
suggested timing phase 3 is 9.8 secs green, 3.0 secs yellow + red clear

APPENDIX C

ROUTE 3 AIR QUALITY ANALYSIS

ENVIRONMENTAL ASSESSMENT /
DRAFT ENVIRONMENTAL IMPACT REPORT

TRANSPORTATION IMPROVEMENTS TO ROUTE 3

BURLINGTON, BEDFORD, BILLERICA, CHELMSFORD LOWELL, WESTFORD AND TYNGSBOROUGH

PRELIMINARY
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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
AND
COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF PUBLIC WORKS

August 1988

5.5 BASELINE AIR QUALITY

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The purpose of this section is to discuss existing pollutant attainment status in the Route 3 corridor and the results of the baseline impact analysis. Since the purpose of this study is to evaluate the air quality impact from vehicles, the pollutants of concern are carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane hydrocarbons (NMHC).

Discussion of Air Quality Standards: The Clean Air Act of 1970 mandated that the Environmental Protection Agency (EPA) establish ambient ceilings for certain criteria pollutants based upon the latest scientific information regarding all identifiable effects a pollutant may have on public health or welfare. Subsequently, EPA promulgated regulations which set National Ambient Air Quality Standards (NAAQS). The State of Massachusetts has established ambient air quality standards for the pollutants of concern, which are the same as the NAAQS. Table 16 lists the state and national ambient standards for these pollutants.

Section 107 of the 1977 Clean Air Act Amendments requires EPA to publish a list of all geographic areas in compliance with the NAAQS as well as those not attaining the NAAQS. Areas not in compliance with the NAAQS are termed nonattainment, and those meeting the NAAQS are referred to as attainment. The entire State of Massachusetts is designated as attaining the NAAQS for NO_2 and non-attaining the NAAQS for Ozone. The City of Lowell is the only area designated as non-attaining the NAAQS for CO in the Route 3 corridor based on DEQE ambient monitoring data.

As part of the requirements of the Clean Air Act, states must formulate a State Implementation Plan (SIP) which describes what measure will be undertaken to comply with and maintain the NAAQS. The Massachusetts SIP specifies transportation control measures for the

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TABLE 16

SUMMARY OF NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)

AND MASSACHSUETTS STATE STANDARDS FOR THE

POLLUTANTS OF CONCERN[1]

Pollutant	Averaging Time	Standards: Primary[1]	Standards: Secondary[2]
Carbon monoxide[3]	8 Hours Average[3] 1 Hour Average[3]	10 mg/m^3 (9 ppm) 40 mg/m^3 (35 ppm)	none
Nitrogen dioxide	Annual Arithmetic Mean	100 ug/m^3 (.05 ppm)	same as primary
Ozone[2]	1 Hour Average[3]	240 ug/m^3 (.12 ppm)	same as primary

[1]Primary standards are designed to protect public health.

[2]Secondary standards are designed to protect the public welfare from any known or anticipated adverse effects of a pollutant.

[3]Not to be exceeded more than once a year.

Sources: Massachusetts Ambient Air Quality Standards, Title 310; 40 CFR 50.4-50.12

non-attainment areas. The Massachusetts State Implementation Plan (MA SIP) was approved by the EPA in November 1983. The Federal Highway Administration (FHWA) has determined that both the transportation plan and transportation improvement programs conform to the SIP. The FHWA has determined that this project is included in the transportation improvement program for the Northern Middlesex Area Commission (NMAC). Therefore, pursuant to 23 CFR 770, this project conforms to the SIP. The air quality analysis undertaken for this project was coordinated with the DEQE, the EPA and the Massachusetts Department of Public Works (MDPW).

Based on the findings described in Chapter 4, the TSM alternative was not analyzed in this study. The level of excess capacity on Route 3 is severe and precludes any realistic chances of substantially improving travel conditions by introducting TSM measures. Anything short of increasing the physical capacity of Route 3 will have a negligible effect on future travel conditions.

Baseline Condition Modeling Results: Traffic volume and travel speeds for the AM/PM peak hours and the highest average 8-hour period for the 1984 baseline conditions were used in a microscale air quality analysis to determine carbon monoxide (CO) concentrations at selected receptors. A microscale analysis considers traffic flow within 1600 feet (approximately 500 meters) of a selected location (receptor), road geometry and meteorological factors to predict CO concentrations from vehicle exhausts. Computer models are used to calculate down wind emissions of CO. These models are described below.

The EPA approved MOBILE3 model was used to calculate CO free flow and idle emission factors. Queuing emission rates for ramps and stop lights were calculated using a method developed by EPA Region I. The EPA approved CALINE3 model was used to determine CO concentrations at selected receptors (see Table 17 and Figures 25 through 28). The CALINE3 model calculations are based on (1) emission factors from MOBILE3, (2) queuing emission rates from the EPA methodology, (3)

TABLE 17

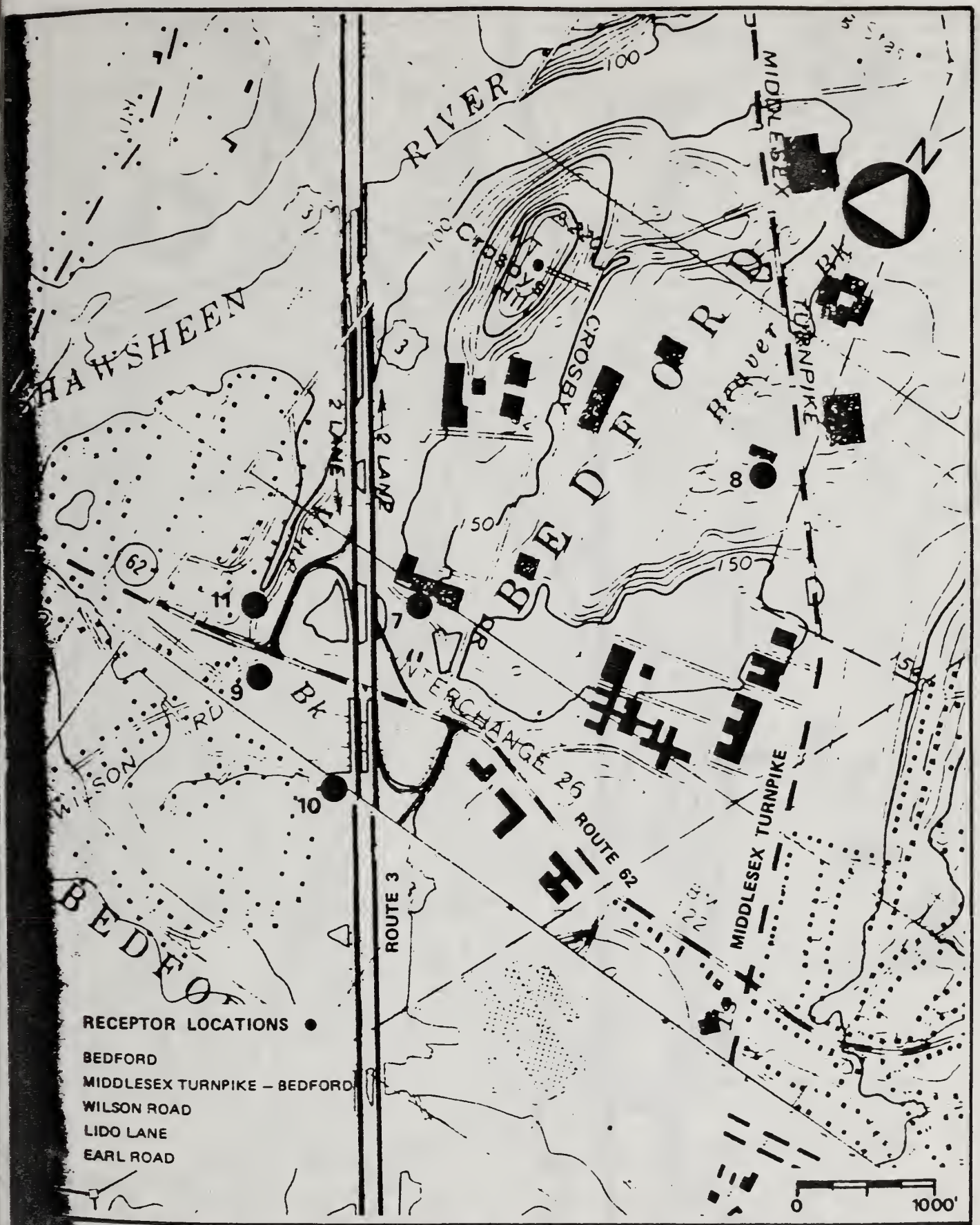
RECEPTOR LOCATIONS USED IN THE AIR QUALITY ANALYSIS FOR THE ROUTE 3 NORTH ADD-A-LANE PROJECT

RECEPTOR	DESCRIPTION
Figure 25 Route 3, Route 128 & Middlessex Turnpike	
No. 1	M/A - Components in Burlington, property just off Middlesex Turnpike.
No. 2	Burlington Dodge, Middlesex Turnpike.
No. 3	U.S. Windpower, Wheeler Road
No. 4	House at North Street and Burlington Street
No. 5	House at Partridge Road.
No. 6	Just off Route 3 Mainline North approximately 120 m North of On Ramp.
Figure 26 Route 3, Route 62 & Middlesex Turnpike	
No. 7	Computer Vision in Bedford
No. 8	Stouffer's Glen Bedford Inn, Middlesex Turnpike
No. 9	House at end of Wilson Road
No. 10	House at Lido Lane close to Route 3 South
No. 11	House at Earl Road
Figure 27 Route 3, Lowell Connector & 495	
No. 12	House approximately 96 m south Route 3 south
No. 13	House nearest to 495/Route 3 Interchange
Figure 28 Route 3 & Middlesex Road Near NH Border	
No. 14	Intersection of Middlesex Road and Route 3 On/Off Ramps
No. 15	Just off Route 3 Mainline North approximately 300 m before Off Ramp.

ROUTE 3 ADD-A-LANE PROJECT • ENVIRONMENTAL ASSESSMENT

FIGURE 25

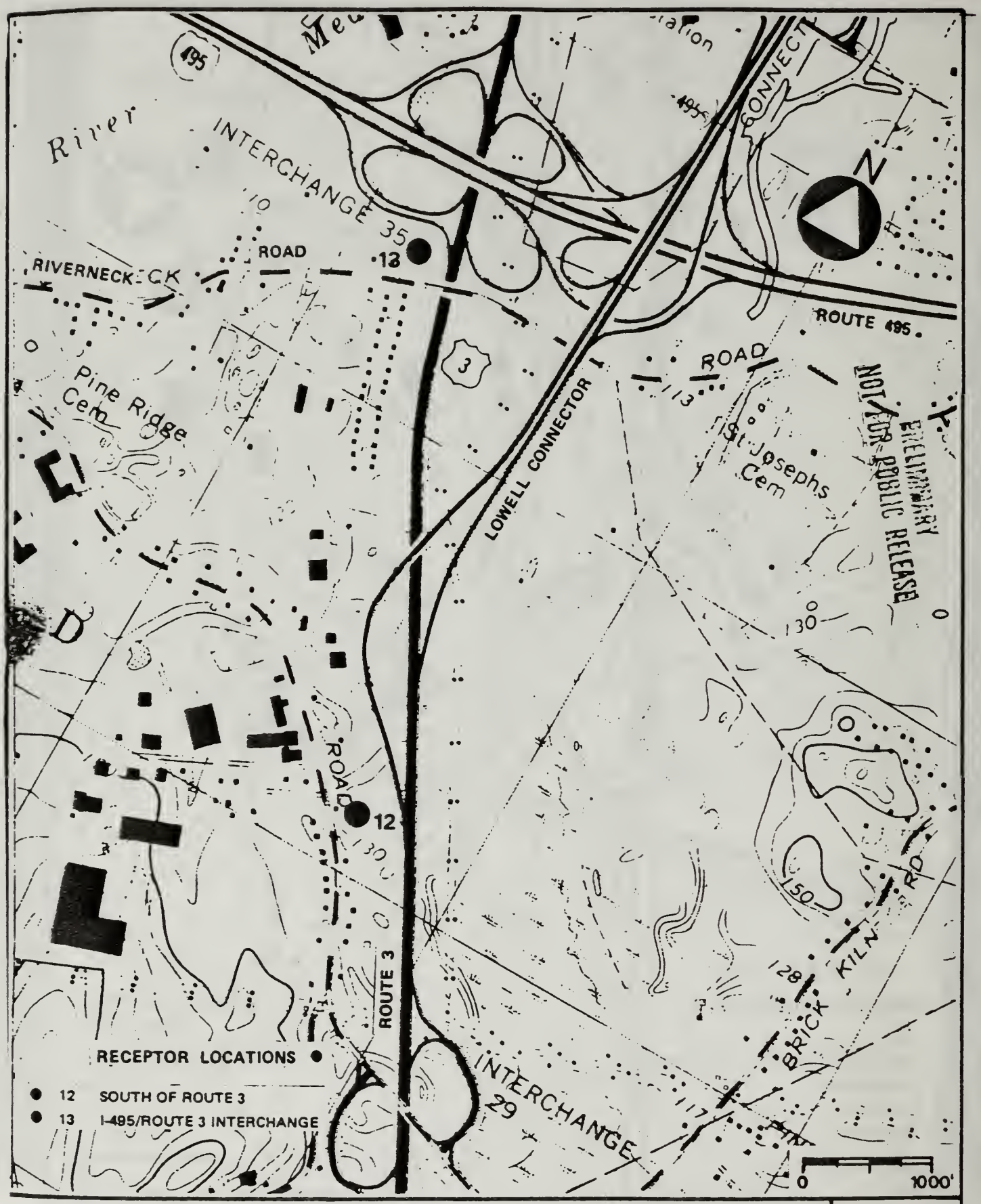
AIR QUALITY RECEPTOR LOCATIONS



ROUTE 3 ADD–A–LANE PROJECT • ENVIRONMENTAL ASSESSMENT

FIGURE 26

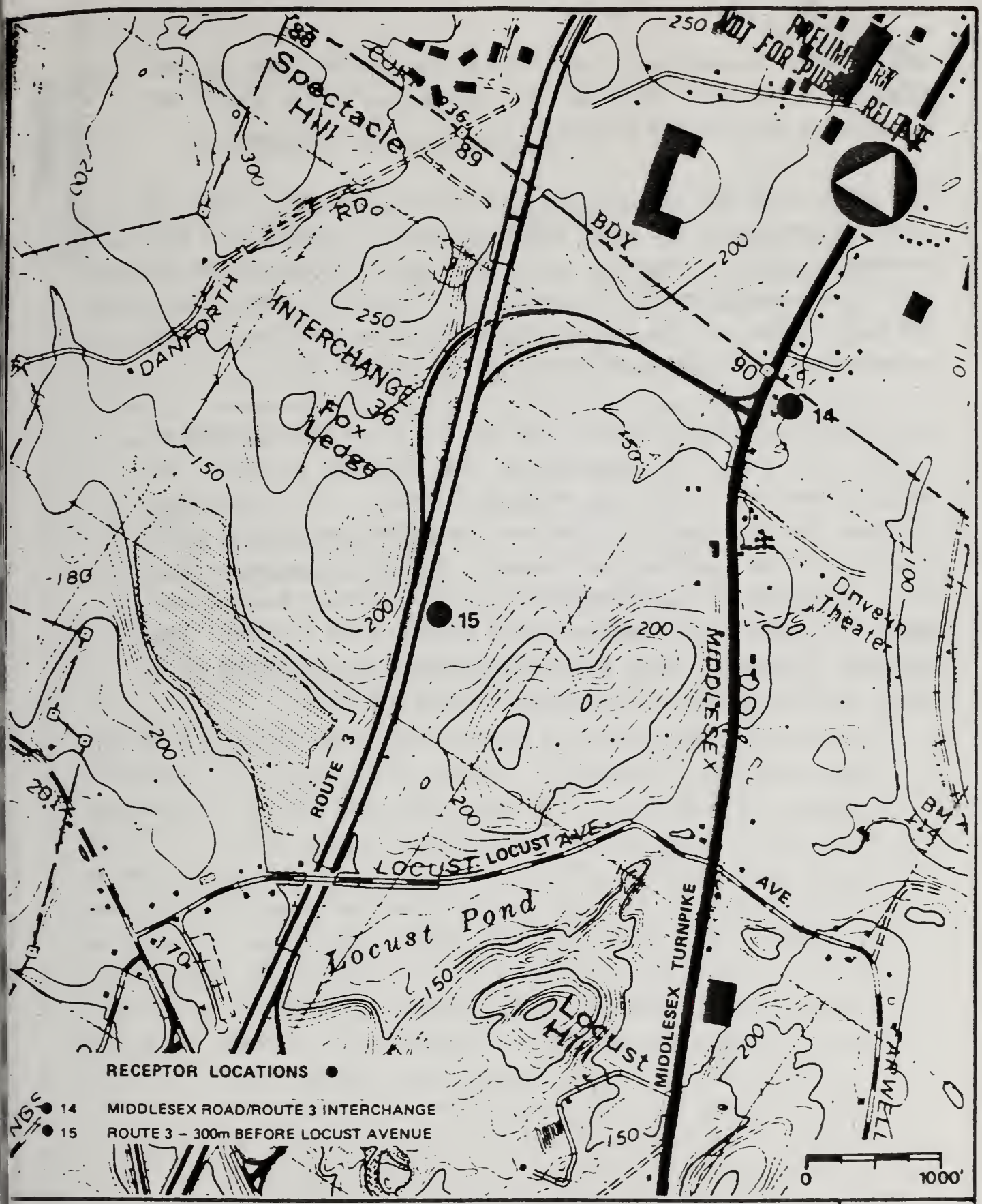
AIR QUALITY RECEPTOR LOCATIONS



ROUTE 3 ADD-A-LANE PROJECT • ENVIRONMENTAL ASSESSMENT

FIGURE 27

AIR QUALITY RECEPTOR LOCATIONS



ROUTE 3 ADD–A–LANE PROJECT • ENVIRONMENTAL ASSESSMENT

FIGURE 28

AIR QUALITY RECEPTOR LOCATIONS

meteorological assumptions as specified by the agencies, and (4) road geometry/traffic data. More detailed information on the models and calculations is presented in Appendix D.

The results of the analysis are listed in Table 18. Total CO concentrations represent model predicted impacts combined with EPA recommended ambient background levels of 3 ppm and 2 ppm for the 1- and 8-hour averaging periods, respectively. The concentrations listed for each receptor are the highest CO concentrations predicted at that receptor considering all wind directions (10° through 360°).

The 1-hour CO concentrations are less than the 1-hour primary NAAQS of 35 ppm. The 8-hour CO concentrations are predicted to exceed the NAAQS at receptors 1 and 2 near Middlesex Turnpike. The receptors at Middlesex Turnpike have high predicted concentrations due to their proximity to the turnpike, and frequency of traffic queues in that area. The 8-hour CO concentrations are less than the 8-hour primary NAAQS of 9 ppm for all receptors except numbers 1 and 2 located near Middlesex Turnpike. These high concentrations are predicted as a result of the proximity of the receptors to the Turnpike.

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6.5 AIR QUALITY

6.5.1 Future Conditions Modeling Results

Traffic demand volume counts and travel speeds for the AM/PM peak hours and in some cases, the highest 8-hour period for the 1990 implementation and 2010 design conditions, were used in a microscale air quality analysis to determine carbon monoxide (CO) concentrations at selected receptors. The modeling methodology used to perform the analysis is described in Technical Appendix D. For the future conditions, EPA recommended the following ambient CO concentrations be used in the analysis:

1990
1-hour background of 2 ppm
8-hour background of 1 ppm

2010
1- and 8- hour background of 1 ppm

The AM/PM peak hour concentrations were determined using the modeling techniques in the referenced appendix. The 8-hour concentration was determined by scaling the highest peak hour concentration by a factor of 0.7. If the 8-hour concentrations determined by using this approach exceed the CO standard of 9 ppm, an analysis using actual 8-hour traffic counts and speeds can be done. This was the case for Receptors 4 and 5 near Route 128 (see Figure 25). However, approximately 90 percent of the concentrations predicted at these receptors were contributed from Route 128. Therefore, by using 8-hour counts and speeds for the roadways at this location, especially on Route 128, the predicted 8-hour concentrations decreased below the standard. The results of the analysis for the 1990 and 2010 conditions are listed in Tables 35 and 36 respectively. The net change in concentrations (Build minus No Build) are listed in Table 38. Results for each analysis year are discussed separately below.

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1990

The 1- and 8-hour total concentrations (predicted plus background concentration) determined for 1990 comply with the ambient CO standards of 35 and 9 ppm respectively with the exception of the 8-hour concentrations at Receptor 14 (see Figure 28). Receptor 14 was originally chosen to represent a home at the intersection of Middlesex Road and the Route 3 on/off ramps near the New Hampshire border. However, this home no longer exists and in its place is the entrance to the Pheasant Lane Mall. This area is heavily travelled especially during the PM peak period. The 8-hour concentration was determined by scaling the highest peak hour concentration by a factor of 0.7.

The net change in concentration listed in Table 37 shows that concentrations at Receptors 1 and 2 at Middlesex Turnpike decreases from No Build to Build conditions. This is attributable to vehicles opting to use an upgraded Route 3 instead of Middlesex Turnpike. Concentrations on Route 3 Mainline either increase or decrease depending on the change in speed and volume. In some cases the widening of Route 3 brings the roadway emissions closer to the receptor resulting in higher concentrations. But in no case are concentrations on Route 3 mainline approaching the CO standards.

2010

The 1- and 8-hour total concentrations determined for 2010 comply with the ambient CO standards of 35 and 9 ppm respectively. Due to a decrease in CO emission factors from 1990 to 2010 attributable to using EPA approved modeling techniques, the 8-hour concentrations predicted at Receptor 14 comply with the ambient CO standard.

Again, the net change in concentrations listed in Table 37 show that concentrations at Receptors 1 and 2 at Middlesex Turnpike decrease from No Build to Build conditions, attributable to vehicles opting to

use an upgraded Route 3. Concentrations on Route 3 Mainline either increase or decrease depending on the change in speed and volume. Again, the widening of Route 3 brings the roadway emissions closer to the receptor resulting in higher concentrations, but concentrations on Route 3 Mainline are less than the CO standards.

TABLE 35

RESULTS OF THE 1990 FUTURE CASE AIR QUALITY IMPACT ANALYSIS

FOR THE ROUTE 3 CORRIDOR

Total CO Concentrations (ppm)

PRELIMINARY
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Receptor	1990 No Build			1990 Build		
	AM Peak	PM Peak	8-Hour	AM Peak	PM Peak	8-Hour
Route 3, Route 128 & Middlesex Turnpike						
No. 1	9.0	9.6	6.3	7.9	8.6	5.6
No. 2	8.1	8.8	5.8	7.4	8.0	5.2
No. 3	9.5	8.5	2.4	10.0	9.4	3.1
No. 4	13.1	11.6	3.3	13.9	12.8	4.0
No. 5	13.3	12.0	3.3	14.1	13.0	3.9
No. 6	8.6	8.0	2.5	9.3	9.9	3.0
Route 3, Route 62 & Middlesex Turnpike						
No. 7	4.4	5.0	3.1	4.8	6.0	3.8
No. 8	3.0	2.9	1.7	3.0	2.8	1.7
No. 9	6.1	6.6	4.2	7.7	8.4	5.5
No. 10	4.3	4.6	2.8	4.6	5.5	3.5
No. 11	6.3	6.6	4.2	7.0	7.7	5.0
Route 3, Lowell Connector & 495						
No. 12	4.4	4.0	2.7	3.8	4.6	2.8
No. 13	4.4	3.9	2.7	5.0	4.5	3.1
Route 3 & Midlesex Road						
No. 14	13.3	14.9	10.0	13.9	14.2	9.5
No. 15	4.7	5.9	3.7	4.5	4.3	2.8

Note: Total concentrations include a 1-hour and 8-hour CO backround concentration of 2ppm and 1ppm respectively.

TABLE 36

RESULTS OF THE 2010 FUTURE CASE AIR QUALITY IMPACT ANALYSIS

FOR THE ROUTE 3 CORRIDOR

Total CO Concentrations (ppm)

	2010 No Build			2010 Build		
Receptor	AM Peak	PM Peak	8-Hour	AM Peak	PM Peak	8-Hour
Route 3, Route 128 & Middlesex Turnpike						
No. 1	7.7	8.5	6.3	5.9	6.5	4.9
No. 2	7.0	7.7	5.7	5.5	6.2	4.6
No. 3	9.8	8.6	4.2	10.3	9.1	4.7
No. 4	13.5	11.9	5.9	14.3	13.1	6.6
No. 5	14.6	12.8	5.9	15.2	13.5	6.3
No. 6	8.3	7.5	3.7	10.0	8.4	4.0
Route 3, Route 62 & Middlesex Turnpike						
No. 7	3.3	3.7	2.9	4.2	4.8	3.7
No. 8	1.8	1.7	1.6	1.8	1.6	1.6
No. 9	4.7	5.3	4.0	6.2	6.7	5.0
No. 10	3.1	3.2	2.5	3.9	4.3	3.3
No. 11	4.9	5.4	4.1	5.9	6.3	4.7
Route 3, Lowell Connector & 495						
No. 12	3.3	3.0	2.6	2.9	2.7	2.3
No. 13	3.7	2.8	2.9	3.5	3.1	2.8
Route 3 & Midlesex Road						
No. 14	10.0	11.4	8.3	10.2	11.0	8.0
No. 15	3.9	4.9	3.7	2.8	3.0	2.4

Note: Total concentrations include a 1-hour and 8-hour CO backround concentration of 1ppm and 1ppm respectively.

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TABLE 37

NET CHANGE IN CO CONCENTRATIONS
NO BUILD - BUILD CONDITIONS

Receptor	Net Change in CO Concentrations (ppm) 1990 AM Peak	1990 PM Peak	1990 8-Hour	2010 AM Peak	2010 PM Peak	2010 8-Hour
Route 3, Route 128 & Middlesex Turnpike						
No. 1	-1.1	-1.0	-0.7	-1.8	-2.0	-1.4
No. 2	-0.7	-0.8	-0.6	-1.5	-1.5	-1.1
No. 3	+0.5	+0.9	+0.7	+0.5	+0.5	+0.5
No. 4	+0.8	+1.2	+0.7	+0.8	+1.2	+0.7
No. 5	+0.8	+1.0	+0.6	+0.6	+0.7	+0.4
No. 6	+0.7	+1.9	+0.5	+1.7	+0.9	+0.3
Route 3, Route 62, & Middlesex Turnpike						
No. 7	+0.4	+1.0	+0.7	+0.9	+1.1	+0.8
No. 8	0.0	-0.1	0.0	0.0	-0.1	0.0
No. 9	+1.6	+1.8	+1.3	+1.5	+1.4	+1.0
No. 10	+0.3	+0.9	+0.7	+0.8	+1.1	+0.8
No. 11	+0.7	+1.1	+0.8	+1.0	+0.9	+0.6
Route 3, Lowell Connector & 495						
No. 12	-0.6	+0.6	+0.1	-0.4	-0.3	-0.3
No. 13	+0.6	+0.6	+0.4	-0.2	+0.3	-0.1
Route 3 & Middlesex Turnpike						
No. 14	+0.6	-0.7	-0.5	+0.2	-0.4	-0.3
No. 15	-0.2	-1.6	-0.7	-1.1	-1.9	-1.3

PRELIMINARY
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6.5.2 Mesoscale Analysis

As part of the air quality analyses required for the Route 3 Add-A-Lane study, a Mesoscale Analysis was performed. A mesoscale analysis considers pollutant emissions from vehicles over a large area. In this case, all of the Route 3 main line was analyzed. The parameters used in this analysis are the average daily traffic (ADT) and associated travel speeds for various segments on Route 3. The MOBILE 3 model was used to compute emission factors (mass of pollutants emitted per mile) of carbon monoxide (CO), nitrogen oxides (NO_X) and non-methane hydrocarbons (NMHC), for the travel speeds for each section of Route 3. The average daily traffic on each section was multiplied by the emission factor representing the travel speed on the section and then by the length (miles) of the section, to determine the daily pollutant emissions (tons per day). The pollutant emissions were summed for each section to determine the total emissions from Route 3 mainline.

The objective of this analysis was to compute emissions of carbon monoxide (CO), nitrogen oxides (NO_X) and non-methane hydrocarbons (NMHC) for Route 3 and to determine the change in pollutant emissions for each year and alternative from the No Build to Build configurations over each study year. The results of the analysis for CO, NO_X and NMHC are presented in Appendix D. A summary of the total daily emissions of pollutants from Route 3 is presented below.

	Emissions (Tons/Day)		
Condition	CO	NO_X	NMHC
1984 No Build	25.7	6.00	4.27
1990			
No Build	34.2	3.84	4.39
Build	18.2	5.54	3.57
2010			
No Build	68.7	4.53	7.22
Build	16.2	4.98	3.23

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CO emissions decrease by 76 percent from the 2010 No Build to Build condition because as vehicle speeds increase, due to the additional lane, CO emissions will decrease. NO_X emissions increase by 1 percent from the 2010 No Build to Build condition. The emissions of NO_X increase as engine temperature increases. Therefore, NO_X emissions increase at highway speeds (50 mph and greater) and at very low speeds (5-10 mph) as a result of the increased engine temperature. For example the emissions of NO_X from an engine are about 8% higher at 50 mph as compared to 30 mph. The emissions at 10 mph are about 25 to 30% higher as compared to 30 mph. Hence, a slight increase in NO_X emissions between the Build and No Build condition occurs. NMHC emissions decrease by 55 percent from the 2010 No Build to Build condition. Like CO, NMHC emissions decrease as vehicle speed increases. Consequently, NMHC emissions are reduced due to an increase in vehicle speeds as a result of the additional lane.

6.5.3 Collector-Distributor Roadway

PRELIMINARY
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Traffic volumes and travel speeds for the AM/PM peak hours and highest average 8-hour period for 1990 and 2010, were used to determine carbon monoxide (CO) concentrations along Route 3 near I-495 and the Lowell Connector resulting from the proposed collector-distributor (C-D) roadway configuration. Traffic volumes and speeds are not projected to change on I-495 or the Lowell Connector due to the C-D configuration. Only Route 3, along the length of the C-D roadway will experience changes in demand volume and vehicle speeds. Concentrations at Receptors 12 and 13 (located just south of the C-D, and near the southbound C-D roadway respectively) were evaluated due to the projected change in traffic distribution on Route 3 and the C-D.

The modeling methodology used in the analysis is described in Section 6.5.2. The EPA recommended CO background concentrations for 1990 and 2010 are the same as those cited in Section 6.5.1 "Future Conditions Modeling Results".

The results of the analysis for the 1990 and 2010 C-D roadway configuration are presented in Table 38. Results of the analysis without the C-D roadway are presented in Tables 35 and 36. The concentrations listed in the table include the EPA recommended CO background concentrations. The C-D roadway analysis concentrations were then compared with the 1990 and 2010 Build concentrations assuming no C-D roadway construction. The net change (C-D roadway minus no C-D roadway concentration) in carbon monoxide concentrations for each time period is listed in Table 39. As can be seen from the table, slight increases in the CO concentration resulted from the C-D roadway configuration for some time periods. CO concentrations will increase slightly because C-D roadway placement brings roadway emissions closer to these two receptors. However, the collector-distributor roadway also diverts traffic from Route 3 thus increasing speeds on that roadway and thereby reducing CO emissions. This decrease in emissions helps to offset the increases in concentration noted above so that in some cases there is no change or even a small decrease in CO concentrations given a C-D roadway configuration.

PRELIMINARY
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TABLE 38

RESULTS OF THE 1990 AND 2010

AIR QUALITY IMPACT ANALYSIS

FOR THE PROPOSED COLLECTOR-DISTRIBUTOR ROADWAY

	Total CO Concentrations (ppm)*					
	1990 Build			2010 Build		
Receptor	AM Peak (1 Hour)	PM Peak (1 Hour)	8-Hour	AM Peak (1 Hour)	PM Peak (1 Hour)	8-Hour
Route 3, Lowell Connector & 495						
No. 12	4.3	4.6	1.6	3.7	5.0	1.8
No. 13	3.5	3.6	1.7	2.9	3.0	1.8

* Total Concentration includes the following EPA recommended background concentrations (ppm).

	1990	2010
1-Hour	2	1
8-Hour	1	1

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TABLE 39

NET CHANGE IN CO CONCENTRATIONS FOR

THE C-D ROADWAY VERSUS NO C-D ROADWAY

	Net Change CO Concentrations (ppm)*					
	1990			2010		
Receptor	AM Peak (1 Hour)	PM Peak (1 Hour)	8-Hour	AM Peak (1 Hour)	PM Peak (1 Hour)	8-Hour
Route 3, Lowell Connector & 495						
No. 12	-0.1	+0.6	-1.1	-0.1	+0.4	-1.0
No. 13	-0.8	-0.3	-1.0	-2.1	-1.5	-1.5

* Net change in (C-D Roadway minus no C-D Roadway) Concentration.

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TRANSPORTATION IMPROVEMENTS TO ROUTE 3

BURLINGTON, BEDFORD, BILLERICA, CHELMSFORD LOWELL, WESTFORD AND TYNGSBOROUGH

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TECHNICAL APPENDIX

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
AND
COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF PUBLIC WORKS

August 1988

APPENDIX D

AIR QUALITY

This Appendix presents detailed information on the mesoscale air quality analysis conducted for this project. The text describes the approach used for this analysis and the tables present a sample calculation and the findings of the analysis.

INDIRECT SOURCE AIR QUALITY MODELING APPROACH

The indirect source modeling methodology used to determine air quality impacts is described in this Appendix. The models and methodology were applied in accordance with the EPA and Massachusetts DEQE recommended procedures. The methodology was also submitted to Maguire on December 2, 1986 who distributed copies to both agencies for their review and comment. The protocol was discussed with the EPA, DEQE and DPW at a meeting on January 5, 1987. The agencies have agreed with the models and methodology used as described below.

MOBILE3

The EPA approved MOBILE3 model was used to compute emission factors for carbon monoxide (CO), oxides of nitrogen (NO_x) and hydrocarbons from motor vehicles. MOBILE3 emission estimates depend on various conditions such as:

- calendar year for which emission are calculated
- vehicle distribution mixture (i.e., percent cars versus percent trucks and buses)
- vehicle speed
- ambient temperature
- Inspection/Maintenance (I/M) and anti-tampering programs.

The model primarily uses the above conditions to weight emissions from the past twenty years to determine the pollutant emission factors. The MOBILE3 model inputs used in this study are listed in Table 1.

The MOBILE3 model computes free flow emission factors (gm/mile) and idle emission factors (gm/min) for the three pollutants. Free flow emissions simply means, emissions from vehicles when they are moving at any speed (i.e., 5-55 mph).

Idle emissions are the pollutants emitted when a vehicle is idling (stopped) at a light or in traffic. These two emission factors are used in the analysis to describe total emissions from vehicles at an intersection.

PRELIMINARY NOT FOR PUBLIC RELEASE

CALINE3

The EPA approved CALINE3 model was used to compute downwind pollutant concentrations from road segments and intersections based on the following input information.

1) free flow emission rates from MOBILE3
2) vehicle queue emissions and lengths from EPA Region I methodology (described below)
3) roadway and intersection geometrics and receptor locations
4) meteorological data
5) surface roughness length

A brief discussion of the input parameters is presented below.

1) & 2) CO emission rates: The free flow and queue emission rates discussed in this Appendix

3) Intersection Geometrics: The CALINE3 model requires each roadway segment to be described in the model as a line source. Based on schematic drawings and field visits to verify receptor locations, ERT prepared roadway configurations for input to the model.

4) Meteorological Data: EPA recommended meteorological data was used for the CALINE3 modeling. This data consisted of:

- wind speed of 1 m/s;
- neutral atmospheric stability; and
- 36 wind directions from 10° through 360°.

The results presented in this study reflect the highest concentrations predicted for all 36 wind directions. The use of this data produces conservative results.

5) Surface Roughness: The CALINE3 model accounts for the surface roughness of the study area. Surface roughness is a measure of the mechanical turbulence generated by air movement over a surface. As the roughness of the surface increases, so does the amount of mechanical turbulence. For example, more mechanical turbulence (wind eddies) is generated by air movement over a city due to tall buildings than is generated by movement over a grassland. The increases mechanical turbulence enhances the dispersion of pollutants. The CALINE3 model documentation recommends surface roughness variables for different various types of surfaces. For this study, ERT used a surface roughness of 20 cm reflecting a mixed environment from pavement to small trees and shrub on either side of Route 3 mainline nd exit ramps.

The CALINE3 model was used with the above input information to compute AM/PM peak hour and 8-hour CO concentrations.

Queue Emissions and Length Analysis

When vehicles are stopped at a light or in traffic, the pollutants emitted from an intersection depend on the idle emissions and the length of the vehicle queue over which the pollutants are emitted. The EPA Region I office has devised a methodology to compute the queue emissions based on idle emission factors from MOBILE3, the volume of vehicles traveling through an intersection, the signal cycle time, and number of

lanes in an intersection. This methodology has been reviewed by the DEQE and has been approved for use on this study. A description of this procedure is presented below.

CALINE3 analyzes CO concentrations from roadways by breaking a highway configuration into parts called links. Each link must have the following input data; the X and Y coordinates of the beginning and end points of the link, the type of link, the vehicles per hour on the link, the emission factor for the vehicles on the link, the height of the link with respect to adjacent terrain and the width of this mixing cell.

When analyzing an intersection with CALINE3, one enters all data for the free flow links as discussed in the user's guide. Then calculation of the queue lengths for the approaching links using appropriate traffic modeling procedures must be done. For this analysis, the length of a vehicle queue was determined by using the EPA approved procedures described in Volume 9 of the "Guidelines for Air Quality Maintenance Planning and Analysis". These procedures were also approved by the agencies for this study. The remaining input data, except for the vehicles per hour (VPH) and emission factors (EF), are determined the same way for the queuing links as they are for the free flow links. The VPH and EF for the queuing links are developed from idle emission factors obtained from the EPA MOBILE3 model.

Normally, the inputs for VPH (numbers of vehicles) and the EF (grams per vehicle mile) are converted by 0.1726 into microgram per meter-second in the equation (from page B-4 of the CALINE3 users manual) for the Linear Source Strength Ql=(0.1726)X(VPH)X(EF). But, the idle EF is in grams per vehicle-minute rather than grams per vehicle-mile. Therefore, EPA recommends a procedure that hand calculates the Total Linear Source Strength and then creates dummy VPH and EF input data that will result in the hand calculted Linear Source Strength being used for the queuing link.

In order to hand calculate the Linear Source Strength, conversion of an idle EF in units of grams per vehicle-minute to micrograms per meter-second must be done. Grams per vehicle-minute converts to micrograms per vehicle-minute by multiplying by a million. Micrograms per vehicle-minute converts to micrograms per vehicle-second by dividing by 60 seconds. Finally, if one assumes a vehicle is approximately 6 meters long in a queue, then micrograms per vehicle-second converts to micrograms per meter second by dividing by 6. These conversions are the equivalent to multiplying the idle EF by 2778. Thus by converting the units of the idle emission factor, the Linear Source Strength for one traffic lane, for one meter over one second can be determined. To determine the total Linear Source strength for a queuing link, one must account for the total number of lanes in the queue link and the percent of time the vehicles can be expected to be ideling in the queue link. This can be done by multiplying the Linear Source Strength for one lane, for one meter over on second by the number of lanes in the link and the percent of red light cycle time. This is shown below.

Q_T = (MOBILE3 Idle Factor) x (2778) x (Number of lanes) x (Percent Red Light Time)

By doing this, the total Linear Source Strength $(Q)_T$ for each queuing link is determined. The objective is to get CALINE3 to use this Q_T for the queuing links. CALINE3 uses the equation Ql=(0.1726X(VPH)X(EF), therefore appropriate input data that will result in CALINE3 using the previously calculated Q_T must be determined. Since the VPH is known from traffic data, the appropriate EF for input to CALINE3 based on Q_T is determined as follows.

$$EF = \frac{Q_T}{(.1726 \times VPH)}$$

Now both the EF and VPH which CALINE3 uses to calculate the appropriate Q_T can be input to the model.

TABLE 1

MOBILE3 INPUT PARAMETERS FOR THE INDIRECT SOURCE ANALYSIS

Parameter	Value	
TAMFLG	1	
SPDFLG	1	
VMFLG[1]	1	
MYMRFG	1	
NEWFLG	1	
IMGLF[2]	2	
ALHFLG	1	
ATPFLG	1	
IFORM	4	
PRTFLG	4	
ICEVFG	1	
IDLFLG	2	
NMHFLG	2	
AMBT(^{o}F by pollutant)	CO 30°	
	NO_x,NMHC 75°	
	1-Hour	8-Hour
PCCN	50.0	20.6
PCHC	10.0	27.3
PCCC	50.0	20.6

[1]VMT Mix Record
Model default assumes national vehicle mix

[2]Inspection/Maintenance Record
83,13,1,*,20,4,1,2,1 where * equals run year minus 15

SAMPLE CALCULATION FOR ROUTE 3 BETWEEN ROUTE 128

AND ROUTE 62 FOR THE 1984 BASELINE CONDITION

	Total Daily Traffic Over Segment (vehicles)	AM Peak Traffic Over Segment (vehicles/mph)	PM Peak Traffic Over Segment (vehicles/mph)	8-Hour Average* Traffic Over Segment (vehicles/mph)	Remaining Traffic Over Segment (vehicles/mph)
NB	33,054	3,499/40	2,912/50	8 x 2,366/55	7,715/55
SB	33,051	3,222/45	3,479/35	8 x 2,473/55	6,566/55

Distance between Route 128 and Route 62 is 2.15 miles.

Sample Calculation for NO_x Emissions**

NB

3,499 vehicles x 2.15 miles x 3.51 gm NO_x/mile

2,912 vehicles x 2.15 miles x 3.90 gm NO_x/mile

18,928 vehicles x 2.15 miles x 4.26 gm NO_x/mile

+ 7,715 vehicles x 2.15 miles x 4.26 gm NO_x/mile

TOTAL DAILY NO_x = 0.33 tons

3,222 vehicles x 2.15 miles x 3.66 gm NO_x/mile

3,479 vehicles x 2.15 miles x 3.42 gm NO_x/mile

19,784 vehicles x 2.15 miles x 4.26 gm NO_x/mile

+ 6,566 vehicles x 2.15 miles x 4.26 gm NO_x/mile

TOTAL DAILY NO_x = 0.32 tons

*Average 8-hour volume multiplied by 8 to determine total vehicles in 8 hours.

**Emission factors listed for NO_x are from MOBILE3 for the speeds listed above.

Calculation was repeated for CO and NMHC.

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PRELIMINARY

TABLE D-1

RESULTS OF THE ROUTE 3 MESOSCALE ANALYSIS

FOR NON-METHANE HYDROCARBONS

Road Segments Between		1984 Pollutant Burden Ton/Day		
		CO	NMHC	NO_X
Route 128 Route 62	NB SB	2.86	0.48	0.67
Route 62 Concord Rd.	NB SB	4.94	0.84	1.15
Concord Rd. Treble Cove Rd.	NB SB	1.95	0.33	0.46
Treble Cove Rd. Route 129	NB SB	3.12	0.53	0.73
Route 129 Lowell Conn.	NB SB	0.87	0.14	0.19
Lowell Conn. Route I-495	NB SB	0.89	0.14	0.21
Route I-495 Route 110	NB SB	0.62	0.10	0.15
Route 110 Drum Hill	NB SB	2.63	0.44	0.59
Drum Hill Route 40	NB SB	2.39	0.40	0.57
Route 40 Westford Rd.	NB SB	2.22	0.38	0.55
Westford Rd. Route 113	NB SB	1.60	0.27	0.41
Route 113 Middlesex Rd.	NB SB	0.88	0.15	0.22
Middlesex Rd. State Line	NB SB	0.39	0.07	0.10
TOTAL		25.36	4.27	6.00

TABLE D-2

RESULTS OF THE ROUTE 3 MESOSCALE ANALYSIS

FOR CARBON MONOXIDE

oad Segments Between		Daily Pollutant Burden for CO (Tons/Day) 1984 No Build	1990 No Build	1990 Build	2010 No Build	2010 Build
oute 128 oute 62	NB SB	2.86	2.41	8.69	1.99	
oute 62 oncord Rd.	NB SB	4.94	3.80	13.31	3.12	
oncord Rd. reble Cove Rd.	NB SB	1.95	1.31	5.58	1.29	
reble Cove Rd. oute 129	NB SB	3.12	2.21	9.69	2.01	
oute 129 owell Conn.	NB SB	.87	0.63	2.87	0.50	
owell Conn. oute I-495	NB SB	.89	0.56	0.38	0.42	
oute I-495 oute 110	NB SB	.62	0.40	1.59	0.41	
oute 110 um Hill	NB SB	2.63	2.10	9.10	1.83	
um Hill ute 40	NB SB	2.39	1.74	7.36	1.72	
ute 40 stford Rd.	NB SB	2.22	1.39	4.91	1.30	
stford Rd. ute 113	NB SB	1.60	0.94	3.13	0.86	
ute 113 idlesex Rd.	NB SB	0.88	0.52	1.51	0.46	
idlesex Rd. ate Line	NB SB	0.39	0.23	0.58	0.21	
AL		25.36	18.24	68.70	16.12	

TABLE D-2

RESULTS OF THE ROUTE 3 MESOSCALE ANALYSIS

FOR CARBON MONOXIDE

Road Segments Between		Daily Pollutant Burden for CO (Tons/Day)				
		1984	1990		2010	
		No Build	No Build	Build	No Build	Build
Route 128	NB	2.86	2.41	8.69	1.99	
Route 62	SB					
Route 62	NB	4.94	3.80	13.31	3.12	
Concord Rd.	SB					
Concord Rd.	NB	1.95	1.31	5.58	1.29	
Treble Cove Rd.	SB					
Treble Cove Rd.	NB	3.12	2.21	9.69	2.01	
Route 129	SB					
Route 129	NB	.87	0.63	2.87	0.50	
Lowell Conn.	SB					
Lowell Conn.	NB	.89	0.56	0.38	0.42	
Route I-495	SB					
Route I-495	NB	.62	0.40	1.59	0.41	
Route 110	SB					
Route 110	NB	2.63	2.10	9.10	1.83	
Drum Hill	SB					
Drum Hill	NB	2.39	1.74	7.36	1.72	
Route 40	SB					
Route 40	NB	2.22	1.39	4.91	1.30	
Westford Rd.	SB					
Westford Rd.	NB	1.60	0.94	3.13	0.86	
Route 113	SB					
Route 113	NB	0.88	0.52	1.51	0.46	
Middlesex Rd.	SB					
Middlesex Rd.	NB	0.39	0.23	0.58	0.21	
State Line	SB					
TOTAL		25.36	18.24	68.70	16.12	

TABLE D-3

RESULTS OF THE ROUTE 3 MESOSCALE ANALYSIS

FOR NITROGEN OXIDES

Road Segments Between		NO_x Emissions (Tons/Day) 1984 No Build	1990 No Build	1990 Build	2010 No Build	2010 Build
Route 128 Route 62	NB SB	0.67	0.69	0.53	0.59	
Route 62 Concord Rd.	NB SB	1.15	1.09	0.77	0.92	
Concord Rd. Treble Cove Rd.	NB SB	0.46	0.41	0.34	0.38	
Treble Cove Rd. Route 129	NB SB	0.73	0.66	0.59	0.59	
Route 129 Lowell Conn.	NB SB	0.19	0.17	0.16	0.15	
Lowell Conn. Route I-495	NB SB	0.21	0.20	0.12	0.17	
Route I-495 Route 110	NB SB	0.15	0.12	0.10	0.12	
Route 110 Drum Hill	NB SB	0.59	0.60	0.57	0.54	
Drum Hill Route 40	NB SB	0.57	0.55	0.50	0.51	
Route 40 Westford Rd.	NB SB	0.55	0.47	0.37	0.45	
Westford Rd. Route 113	NB SB	0.41	0.32	0.27	0.31	
Route 113 Middlesex Rd.	NB SB	0.22	0.18	0.15	0.17	
Middlesex Rd. State Line	NB SB	0.10	0.08	0.06	0.08	
TOTAL		6.00	5.54	4.53	4.98	

TABLE D-3

RESULTS OF THE ROUTE 3 MESOSCALE ANALYSIS

FOR NITROGEN OXIDES

PRELIMINARY
NOT FOR PUBLIC RELEASE

Road Segments Between		NO_x Emissions (Tons/Day) 1984 No Build	1990 No Build	1990 Build	2010 No Build	2010 Build
Route 128	NB	0.67	0.69	0.53	0.59	
Route 62	SB					
Route 62	NB	1.15	1.09	0.77	0.92	
Concord Rd.	SB					
Concord Rd.	NB	0.46	0.41	0.34	0.38	
Treble Cove Rd.	SB					
Treble Cove Rd.	NB	0.73	0.66	0.59	0.59	
Route 129	SB					
Route 129	NB	0.19	0.17	0.16	0.15	
Lowell Conn.	SB					
Lowell Conn.	NB	0.21	0.20	0.12	0.17	
Route I-495	SB					
Route I-495	NB	0.15	0.12	0.10	0.12	
Route 110	SB					
Route 110	NB	0.59	0.60	0.57	0.54	
Drum Hill	SB					
Drum Hill	NB	0.57	0.55	0.50	0.51	
Route 40	SB					
Route 40	NB	0.55	0.47	0.37	0.45	
Westford Rd.	SB					
Westford Rd.	NB	0.41	0.32	0.27	0.31	
Route 113	SB					
Route 113	NB	0.22	0.18	0.15	0.17	
Middlesex Rd.	SB					
Middlesex Rd.	NB	0.10	0.08	0.06	0.08	
State Line	SB					
TOTAL		6.00	5.54	4.53	4.98	

TABLE D-4

RESULTS OF THE ROUTE 3 MESOSCALE ANALYSIS

FOR NON-METHANE HYDROCARBONS

Road Segments Between		NMHC Emissions (Tons/Day) 1984 No Build	1990 No Build	1990 Build	2010 No Build	2010 Build
Route 128 Route 62	NB SB	0.48	0.46	0.90	0.39	
Route 62 Concord Rd.	NB SB	0.84	0.73	1.37	0.61	
Concord Rd. Treble Cove Rd.	NB SB	0.33	0.26	0.58	0.25	
Treble Cove Rd. Route 129	NB SB	0.53	0.43	1.00	0.40	
Route 129 Lowell Conn.	NB SB	0.14	0.12	0.30	0.10	
Lowell Conn. Route I-495	NB SB	0.14	0.11	0.08	0.09	
Route I-495 Route 110	NB SB	0.10	0.08	0.17	0.08	
Route 110 Drum Hill	NB SB	0.44	0.40	0.94	0.36	
Drum Hill Route 40	NB SB	0.40	0.35	0.77	0.34	
Route 40 Westford Rd.	NB SB	0.38	0.28	0.52	0.27	
Westford Rd. Route 113	NB SB	0.27	0.19	0.35	0.19	
Route 113 Middlesex Rd.	NB SB	0.15	0.11	0.17	0.10	
Middlesex Rd. State Line	NB SB	0.07	0.05	0.07	0.05	
TOTAL		4.27	3.57	7.22	3.23	

APPENDIX D

ROUTE 38 AIR QUALITY ANALYSIS

AIR QUALITY

INTRODUCTION

An air quality assessment was completed pursuant to the Massachusetts Environmental Protection Agency's (MEPA) draft record of decision requiring a microscale analysis for carbon monoxide based on the K-Mart expansion at Stadium Plaza project (EOEA #8797) in Lowell, Massachusetts. The air quality analysis was completed in conformance with the Department of Environmental Protection, Division of Air Quality (DEP/DAQC) guidelines. The MEPA unit has determined a microscale analysis for carbon monoxide, CO, is warranted based on the proposed increase in daily traffic associated with the proposed K-Mart. DEP/DAQC requires quantification of existing and future air quality to estimate the impact of the project and resultant mitigation if necessitated.

The study scope for air quality is to determine if the proposed K-Mart expansion to Stadium Plaza will interfere with the attainment or maintenance of Massachusetts and National Ambient Air Quality Standards (NAAQS) for carbon monoxide (CO). The NAAQS were established by the Federal Clean Air Act, and are designed to promote and protect the welfare and health of the public. Compliance with these standards must be demonstrated for areas with measurable human activity, referred to as sensitive receptors; potentially exposed to air pollutants emitted by motor vehicles in the study area. Carbon monoxide is the pollutant of concern, standard modelling procedures required by DEP/DAQC were used to estimate CO levels at these sensitive receptors for the project alternatives - 1992 Existing, 1997 No-Build, and 1997 Build. Comparison of the projected pollutant levels for the project alternatives are compared to the NAAQS to evaluate if any violations in air quality standards exist or are expected to occur as a result of this project.

METHODOLOGY

National Ambient Air Quality Standards, NAAQS, for carbon monoxide have been set forth by the United States Environmental Protection Agency (USEPA) which are adopted by the State of Massachusetts as their standard. NAAQS for the 1-hour period sets the maximum concentration for CO at 35 parts per million (ppm) and 9 ppm for the 8-hour period. These primary standards are not to be exceeded more than once a year.

Carbon monoxide is an air pollutant occurring in concentrations along roadway corridors where substantial amount of motor vehicles travel. Motor vehicles are the primary source of CO, the highest concentrations of this pollutant are persistent along roadway corridors where the affects of intersection idling, and queuing in combination with the acceleration and deceleration of motor vehicles tends to increase CO.

The methodology employed to estimate carbon monoxide (CO) microscale analysis consists of two steps. The first is to develop appropriate vehicle emission factors for each study area (1992, and 1997). The second involves applying a pollutant dispersion model which calculates CO concentrations at selected sensitive receptors. The dispersion model incorporates the emission information with meteorological and traffic volume data for each study year and estimates the CO levels expected in the project area.

Emission Rates

MOBILE 4.1[1] is a mathematical computer model used to calculate the CO emissions from the vehicle fleet as a function of traffic flow characteristics. CO emission rates used in this study are based on suggested input parameters by MDEP/DAQC in their March 10, 1992 letter.[2] Emission rates for the peak 1- and 8-hour periods are based on posted speed limits and average running speeds along the project corridor. These speeds represent free-flow conditions between intersections. Excess emissions due to idling in queues at intersections are also calculated by MOBILE 4.1. The generated MOBILE 4.1 emission factors for the study year alternatives are included in the Appendix.

1/ *User's Guide to MOBILE 4.1 (Mobile Source Emission Factor Model) EPA-AA-TEB-91-01; US EPA, Ann Arbor, MI (July 1991).*

2/ *March 10, 1992 Letter from Jon Anderson Department of Environmental Protection - Division of Air Quality Control. Refer To Appendix.*

Dispersion Model

The computer program CAL3QHC[3] is the line dispersion model that predicts CO concentrations at selected receptor locations. Multiple receptors were used at each intersection and were located based on land use i.e., residences, playgrounds, etc. - where human activity is likely to occur for a period of time. Receptors are placed at 3 meters from the edge of pavement and along a certain distance (10, 20, 30 meters).

The pollutant dispersion model utilizes emission factors generated by the MOBILE 4.1 program in addition to meteorological data with roadway geometry and traffic volume information to estimate CO concentrations. The specific input parameters used to run the CAL3QHC model are tabulated in the Appendix are are consistent with the MDEP/DAQC suggested input parameters. The 1-hour and 8-hour analyses were completed using the predicted 8-hour concentrations based on 8-hour average traffic volumes then applying a persistence factor to the 8-hour concentrations to develop the 1-hour concentration.

The persistence factor is developed by calculating the ratio of the 8-hour CO concentrations to the 1-hour. To do this, actual monitoring data collected by the Commonwealth of Massachusetts for CO in the Lowell area was used.[4] The ratio of the maximum 8-hour concentration sampled to the 1-hour resulted in a persistence factor of 1.6. This factor is applied to the 8-hour concentrations from the CAL3QHC model to estimate the 1-hour CO concentrations in ppm. Refer to Appendix for calculations.

Traffic Volumes

Traffic volume data for the roadway corridor were based on 1988 data developed for the Route 38 Transportation Improvement Project[5] and checked with collected 1992 traffic volume information. On a daily basis, the 1992 Existing traffic data was an average of 6% lower than the 1988 traffic data for the corridor. Hence, due to the existence of a more extensive traffic volume base network provided for 1988 along the corridor and at the intersections in addition

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3/ *Users Guide to CAL3QHC, A Modelling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections, Parsons Brinckerhoff Quade & Douglas, Inc. New York, September 1990.*

4/ *1990 Air Quality Report, Commonwealth of Massachusetts Executive Office of Environmental Affairs, Department of Environmental Protection, Division of Air Quality, Boston, Massachusetts*

5/ *Functional Design Report Transportation Improvement Project, Route 38 (Rogers Street), Lowell, Mass. Vanasse Hangen Brustlin, Inc. November 22, 1989.*

to the 1988 being 6% greater, the 1988 traffic volumes were used and called 1992 Existing, adding conservatism to the analysis. The 8-hour volumes which represent the average hour of the eight highest consecutive peak hours of the day were developed using twenty-four hour traffic volume data and applying the ratio to the peak hour traffic counts. The 1-hour traffic is representative of the evening peak hour of the day. Refer to the Appendix for traffic volume documentation.

Background Air Quality

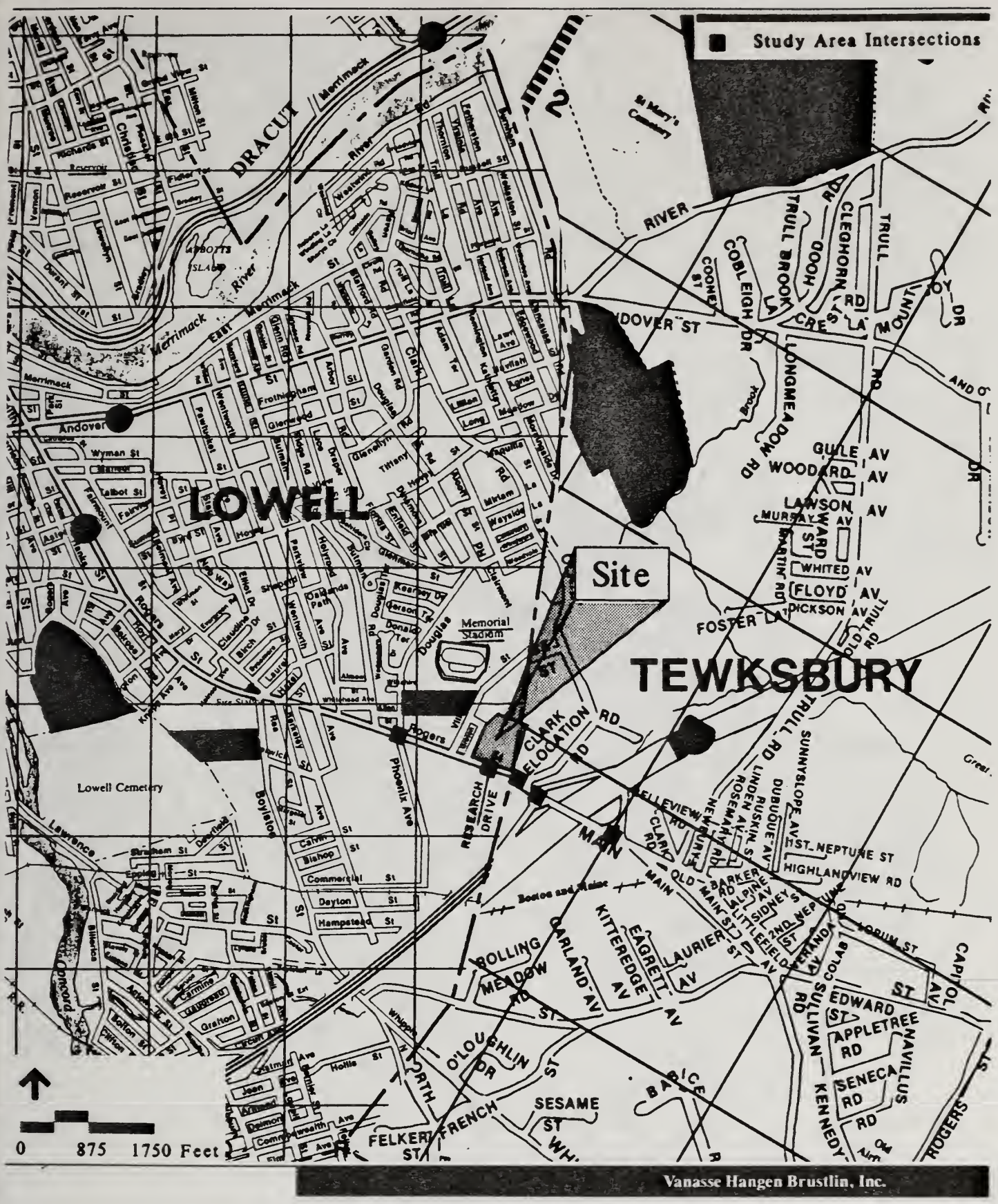
Background air quality or ambient concentration for CO that represent conditions that exist in the study area are determined by MDEP/DAQC. Lowell Massachusetts is classified as an urban area that is in attainment for CO. The 1-hour background ambient is 5.0 ppm and the 8-hour ambient is 3.0 ppm. These concentrations are the base air quality conditions to which the predicted concentrations from the CAL3HQC model are added, to develop the total concentration at a selected site. In the future it is anticipated the ambient emissions will decrease as vehicle fleets are upgraded. By using a ratio of CO emissions for all existing 1992 and future year 1997 in combination with the growth trend in the alternative years the background CO concentrations are expected to be 3.9 and 2.4 ppm for the 1-hour and 8-hour analysis, respectively. This methodology found in the Appendix is approved by MDEP/DACQ.[6]

AFFECTED ENVIRONMENT

It is proposed to expand the existing Stadium Plaza in the City of Lowell and Town of Tewksbury currently housing a Market Basket Supermarket, a Calverts clothing store and other smaller retail stores. The existing buildings consist of approximately 169,875 square feet (sf) of retail use. The proposed K-Mart expansion will consist of the addition of a total of 115,536 s.f. to include a 100,463 K-Mart store and 11,040 s.f. of open air garden shop. The existing site has access to Clark Road, a new direct access to Route 38 (Rogers Street) will be provided across from the Lowell Research Center Drive and the Clark Road access will be closed as part of this project. Figure 1 presents the project site location in vicinity of the local and regional roadway network.

Route 38 is a principal commuter route between Lowell and Interstate 495 (I-495) and also services commercial business developed along it. As such, the roadway experiences heavy peak hour and daily traffic volumes. The Massachusetts Department of Public Works will be reconstructing a portion of Route 38 in the project area.

6/ ***March 13, 1992 Correspondence to MDEP from Vanasse Hangen Brustlin, Inc.***



Site Location/Study Area Map

Figure 1

Vanasse Hangen Brustlin, Inc.

Route 38
Transportation
Improvement Program
Location Map

Figure 2

The Transportation Improvement Program (TIP) for Route 38 will widen the roadway to provide two through lanes of traffic in addition to signalizing major intersections. Left turn lanes will be added to the intersection approaches to increase capacity. The corridor presently experiences capacity conditions during peak hour traffic flow. With the proposed roadway geometry, levels of service along the roadway will increase and provide greater progression to traffic flow through the area. The Route 38 TIP is an approved roadway project scheduled for construction in the Spring of 1993. Figure 2 illustrates the Route 38 TIP study area.

The microscale air quality analysis includes five intersections along the Route 38 corridor that were previously studied in the TIP.[7] The MEPA scope requires a microscale analysis for any study area intersections operating at Level of Service (LOS) D and/or where the proposed project adds 10 percent or more to the traffic volumes. The intersections included in the air quality analysis are listed below:

- Route 38/Phoenix Avenue/Douglas Road
- Route 38/Lowell Research Center Drive/(Stadium Plaza Access Drive)
- Route 38/Clark Road
- Route 38/I-495 Southbound Ramps
- Route 38/I-495 Northbound Ramps

The study area including these five intersections are modelled using the CAL3HQC computer program for the 1992 Existing, 1997 No-Build and 1997 Build alternatives. The 1992 existing conditions incorporate existing traffic volumes with present day road geometry. The 1997 No-Build alternative represents the roadway in a five-year horizon with traffic anticipated to increase over existing due to background developments to be constructed and areawide growth in this region. The Route 38 improvement project will be in place, hence the upgraded roadway geometry will be modelled for the future year analysis. In the 1997 Build scenario the K-Mart traffic generation will be introduced to the roadway network with the improved roadway, and modelled to estimate future year air pollutant levels.

7/ *Op. Cit. p. 3.*

Selected areas have been chosen along the study corridor as receptor locations representing land uses considered sensitive or areas where CO concentrations are expected to be persistent. Table 1 presents the receptor location by identification number along the study area corridor. Figure 3 illustrates the locations of these receptor locations. A total of six receptor sites were chosen along the study corridor representing similar land uses that are susceptible to motor vehicle emitting pollutants.

Table 1 **Air Quality Receptors**

Receptor No. *	Receptor Location/Description
1	Residences @ Route 38/Phoenix Avenue/Douglas Road
2	Residences & Park Area @ Route 38/Village Avenue/Groton Street
3	Commercial use @ Route 38/Lowell Research Center Drive/Stadium Plaza Access Drive
4	Commercial Use @ Route 38/Clark Road
5	Commercial use @ Route 38/I-495 SB Ramps
6	Residences @ Route 38/I-495 NB Ramps

Notes:

* Refer to Figure 3 for Receptor Locations

Vanasse Hangen Brustlin, Inc.

Air Quality Receptor Locations Figure 3

CONCLUSIONS

The microscale analysis demonstrates that the proposed project will not have an adverse impact on air quality. The results, presented in Table 2, do not violate the carbon monoxide criteria in the Massachusetts State Implementation Plan which states that a proposed project cannot cause a new carbon monoxide violation, nor can it exacerbate an existing violation. In general, the carbon monoxide levels continue to improve from 1992 to 1997 at all locations except at the intersection of Route 38 and Clark Road. This intersection will experience an increase in carbon monoxide levels due to the proposed project. However,this increase is not signficant. Finally, the air quality analysis indicates that the project area is in attainment for carbon monoxide and can be expected to remain in attainment due to Massachusetts' Inspection and Maintenance Program and the Federal Motor Vehicle Emission Control Program (new vehicle standards).

Table 2 Carbon Monoxide Results

One Hour Values
(One Hour Standard = 35 Parts Per Million)

Location	1992 No Build	1997 No Build	1997 Build
Receptor 1	11.2	7.0	7.0
Receptor 2	9.4	8.8	9.6
Receptor 3	10.4	9.9	10.2
Receptor 4	10.7	10.6	12.3
Receptor 5	12.0	10.7	11.0
Receptor 6	9.6	8.6	9.3

Table 3 Carbon Monoxide Results

Eight Hour Values
(Eight Hour Standard = 9 Parts Per Million)

Location	1992 No Build	1997 No Build	1997 Build
Receptor 1	7.0	4.4	4.4
Receptor 2	5.9	5.5	6.0
Receptor 3	6.5	6.2	6.4
Receptor 4	6.7	6.6	7.7
Receptor 5	7.5	6.7	6.9
Receptor 6	6.0	5.4	5.8

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